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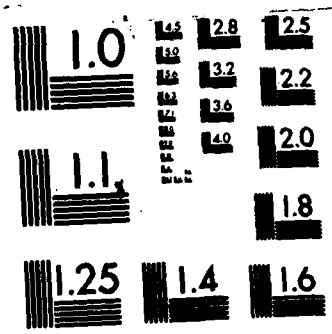

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This report is one of 23 subbasin reports produced by the St. Paul District Corps of Engineers in connection with a reconnaissance report for the whole of the Red River Basin. The reconnaissance report is itself part of the overall Red River of the North study, which was initiated by Congress in 1957 in order to develop solutions for flooding problems within the basin.

The purpose of a reconnaissance study is to provide an overview of the water and related land resource problems and needs within a particular geographic area, to identify planning objectives, to assess potential solutions and

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problems, to determine priorities for immediate and longrange action, and to identify the capabilities of various governmental units for implementing the actions.

The information developed in this report has been combined with information developed in the other subbasin reports to produce a main report covering the basin as a whole. The various flood control measures discussed in this and in other subbasin reports are combined in the main report to develop the outline of an integrated flood control plan for the basin within the context of a comprehensive plan.

The Main Stem Subbasin is an irregular-shaped area that occupies 2,477 square miles of Minnesota and North Dakota. The subbasin inclues all of the land which drains directly into the Red River main stem. Drainage areas at the confluence of the Main Stem and its tributaries are undifferentiated; hence, the Main Stem boundaries as defined are arbitrary delineations in the sense that part of the land in most of the other subbasins could be included in the Main Stem Subbasin.

GSRI GULF SOUTH RESEARCH INSTITUTE
P.O. Box 14787 Telephone Area Code 504 766-3300 Baton Rouge, Louisiana 70898

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RECONNAISSANCE REPORT:
RED RIVER OF THE NORTH BASIN,
MAIN STEM SUBBASIN

Prepared for:

U.S. Army Corps of Engineers
St. Paul District
St. Paul, Minnesota

TABLE OF CONTENTS

TABLE OF CONTENTS (Cont'd)

TABLE OF CONTENTS (Cont'd)

LIST OF TABLES

LIST OF TABLES
(Contd)

LIST OF ILLUSTRATIONS

I. THE STUDY AND REPORT

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This report is one of 23 subbasin reports produced by the St. Paul District Corps of Engineers in connection with a reconnaissance report for the whole of the Red River Basin. The reconnaissance report is itself part of the overall Red River of the North Study, which was initiated by Congress in 1957 in order to develop solutions for flooding problems within the basin.

The purpose of a reconnaissance study is to provide an overview of the water and related land resource problems and needs within a particular geographic area, to identify planning objectives, to assess potential solutions and problems, to determine priorities for immediate and long-range action, and to identify the capabilities of various governmental units for implementing the actions.

The Main Stem Subbasin is a water resource planning unit located along the Minnesota-North Dakota border are as that form the central portion of the Red River Basin. This report describes the social, economic, and environmental resources of the subbasin, identifies the water-related problems, needs, and desires, and suggests measures for meeting the needs, particularly in the area of flood control.

The report was prepared almost entirely on the basis of secondary information. However, some telephone contacts were made to verify information and to acquire a more complete picture of local conditions. The subbasin has been examined in a comprehensive fashion several times. The following comprehensive reports have been produced:

1. Red River of the North Basin Plan of Study for Water Resources Management prepared in April 1977 by the Army Corps of Engineers, St. Paul District.

2. Red River of the North Interim Feasibility Study, Main Stem Plan of Study, which was prepared in 1978 by the St. Paul District Corps of Engineers. The plan of study describes the study objectives and outlines alternatives that were evaluated in light of water and related land resource needs in the study area.

3. Red River of the North Main Stem Interim Study, Flood Control Alternatives Notebook, which was published in 1979 by the St. Paul District Corps of Engineers. The Interim Study makes an indepth assessment of the agricultural flood problems along the Main Stem and evaluates the effectiveness of flood control alternatives.

4. Red River of the North Regional Flood Analysis (Breckenridge to International Boundary), a report prepared jointly by the North Dakota State Water Commission and the Minnesota Department of Natural Resources in cooperation with the U.S. Department of Agriculture, U.S. Army Corps of Engineers, and the U.S. Geological Survey.

Other published sources on the subbasin include:

1. City of East Grand Forks, Minnesota Civil Defense Flood Fight Plan prepared by Dr. Orley D. Gunderson, Civil Defense Director, and Floan-Sanders, Inc., Consulting Engineer, East Grand Forks, Minnesota, in September 1980 for the Army Corps of Engineers, St. Paul District.

2. Fargo-Moorhead Urban Water Resources Study Reconnaissance Report prepared in September 1980 by the Army Corps of Engineers, St. Paul District.

3. Grand Forks-East Grand Forks Urban Water Resources Study, Plan of Study, prepared in 1976 by K. B. MacKichan and Associates for the St. Paul District Corps of Engineers. The Plan of Study specifies the scope of the study and outlines initial problems, issues and concerns relative to the study area.

4. Grand Forks-East Grand Forks Urban Water Resources Study, Stage 2 Floodplain Management Appendix, prepared in 1978 by the St. Paul District Army Corps of Engineers. The report reviews the adequacy and economic feasibility of authorized flood protection, adequacy of existing measures and feasibility of upgrading the authorized plan.

5. Grand Forks-East Grand Forks Urban Water Resources Study, Leisure Time Analysis, and Background Appendices (Stage 2), prepared in 1978 by the St. Paul District Army Corps of Engineers. The reports examine the problems and needs of water and related land resources in the study area.

6. Grand Forks-East Grand Forks Urban Water Resources Study, Stage 3 Flood Control, Energy Conservation and Recreation, Public Involvement, and Plan Formulation Appendices prepared in December 1979 by the Army Corps of Engineers, St. Paul District.

7. Grand Forks-East Grand Forks Wastewater Study, Stage 3 Grand Forks Combined Sewer Analysis prepared by Stanley Consultants, Muscatine, Iowa, for the Army Corps of Engineers, St. Paul District.

8. Grand Forks-East Grand Forks Urban Water Resources Study, Stage 3 Water Supply Study Final Report prepared in March 1980 by Stanley Consultants, Muscatine, Iowa, for the Army Corps of Engineers, St. Paul District.

9. Ground Water in the Fargo-Moorhead Area, North Dakota and Minnesota, prepared in 1946 by the U.S. Geological Survey in cooperation with the North Dakota Geological Survey, North Dakota Water Conservation Commission, Minnesota Department of Conservation Commission, cities of Fargo and Moorhead, as well as Cass and Clay Counties.

10. Fargo-Moorhead 12th/15th Avenue River Crossing, Environmental Assessment Worksheet, prepared in 1979 by the cities of Fargo and Moorhead with the assistance of Bather, Ringrose, Wolsfeld, Jarvis, Gardner, Inc. and Houston Engineering, Inc.

11. Flood Plain Information, Red River of the North, Fargo, North Dakota-Moorhead, Minnesota, which was prepared in 1972 by the St. Paul District of the Army Corps of Engineers. The report includes a history of flooding in the study area, pinpoints areas of possible future floods, and furnishes a basis for land use controls in the flood plain.

12. Flood Control, Reconnaissance Report, Red River of the North at Halstad, Minnesota, which was prepared in 1976 by the St. Paul District of the Corps of Engineers. The report examines the history of flooding in the municipal area, enumerates damages and examines the feasibility of a flood control project for the city.

13. Flood Control Reconnaissance Report, Argusville, North Dakota, which was prepared in 1977 by the St. Paul District Corps of Engineers. The report examines the feasibility of developing a small flood control project for the city of Argusville.

14. Flood Emergency Plan for Grand Forks, North Dakota, prepared in August 1980 by the Army Corps of Engineers, St. Paul District.

15. (6 MCAR, 1.5400) Criteria for Regulating Agricultural Dike Construction along the Red River of the North and Bois de Sioux Rivers, which were established in 1979 to provide for the orderly and consistent review of applications to relocate, construct or rebuild dikes. The legislation assures that the proposed activities are in the best interest of Minnesota and North Dakota citizens.

16. A Status Report of Water Resources Planning and Development in North Dakota, which was prepared in 1979 by the St. Paul District of the Army Corps of Engineers to report the progress of the Main Stem study.

17. Progress Report of the Red River of the North Main Stem Study, issued by the St. Paul District Corps of Engineers, outlines the purpose and development of the study and an organizational chart for the study process.

18. A design for Tomorrow, The Type II Study, the Main Stem, which was published in 1970 by the Souris-Red-Rainy River Basins Commission and outlines the comprehensive and coordinated Type II Study approved by the Water Resources Council.

19. The Watershed Work Plan, St. Thomas-Lodema Watershed, which was prepared in 1964 by the Pembina County Soil Conservation District and the Pembina County Water Management District.

20. The Work Plan, Joe River Watershed, Kittson County, which was prepared in 1963 by the Kittson Board of County Commissioners.

21. Water Resources Planning and Development in North Dakota, East Grand Forks, Fargo-Moorhead, prepared in 1979 by the St. Paul District Corps of Engineers.

22. Red River of the North Main Stem Hydrologic Data, prepared by the St. Paul District Corps of Engineers in 1977, includes a preliminary analysis of the impacts existing and proposed levee systems in light of known hydrologic conditions in the Main Stem area.

23. Red River of the North Drainage Basin, Minnesota, South Dakota, and North Dakota, a letter from the Secretary of the Army to the Committee on Public Works that was transmitted to Congress on May 24, 1948.

24. Red River of the North, Minnesota and North Dakota, A letter from the Secretary of War to the Committee on Rivers and Harbors, which was transmitted to Congress March 12, 1912.

In addition to these reports, the Main Stem Subbasin received partial coverage in the Souris-Red-Rainy River Basins Comprehensive Study, which was published in 1972 by the Souris-Red-Rainy River Basins Commission, and in the Red River of the North Basin Plan of Study, which was published by the St. Paul District Corps of Engineers in 1977. Problem areas and water issues of the Main Stem also received partial coverage in a Specific Problem Analysis Report, Volumes 1 and 2 of the Upper Mississippi and Souris-Red-Rainy Regions, which was published in 1977 by the Upper Mississippi River Basin Commission.

The information developed in this report has been combined with information developed in the other subbasin reports to produce a main report covering the basin as a whole. The various flood control measures discussed in this and in other subbasin reports are combined in the main report to develop the outline of an integrated flood control plan for the basin within the context of a comprehensive plan.

II. DESCRIPTION OF STUDY AREA

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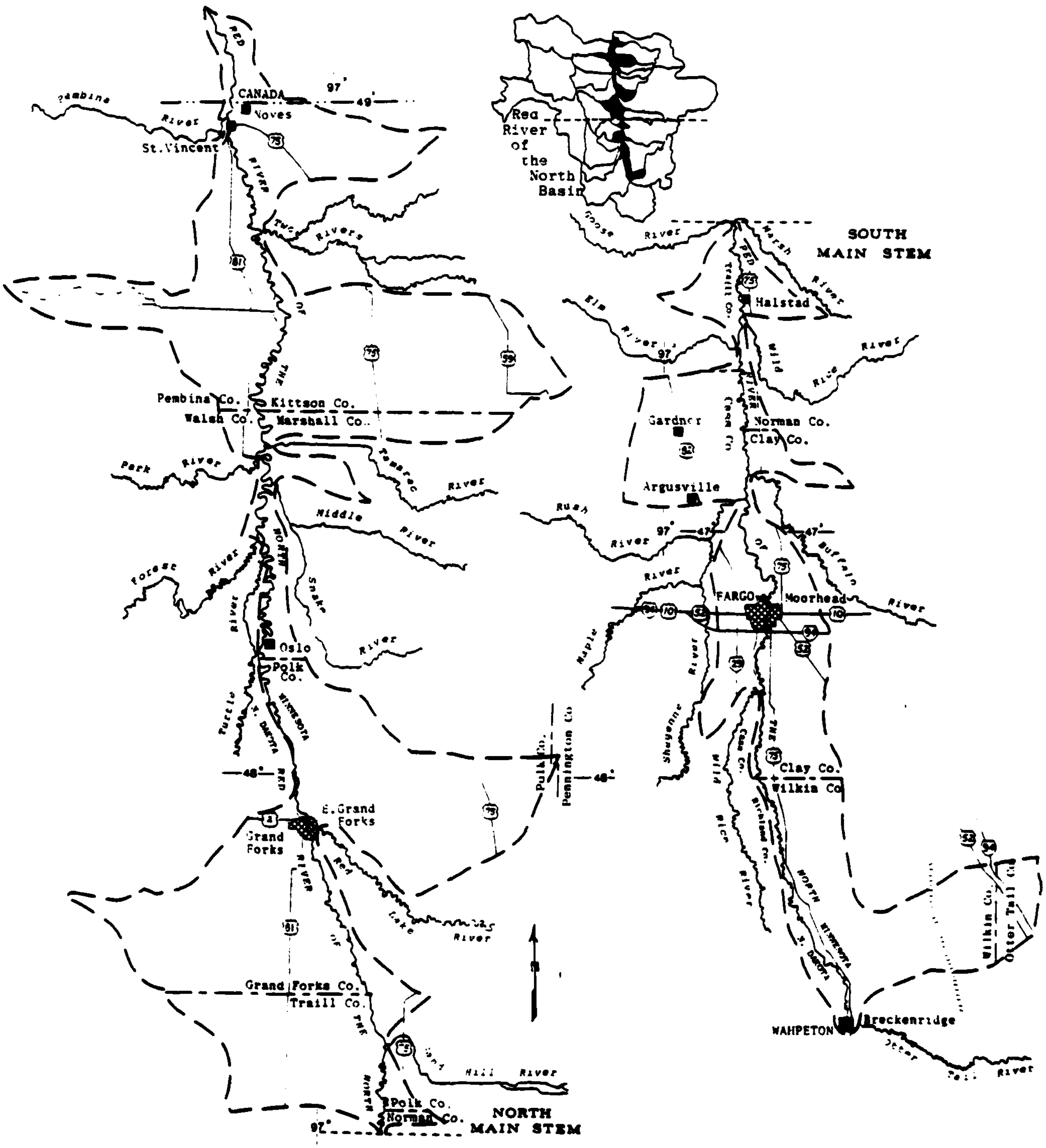
The Main Stem Subbasin is an irregular-shaped area that occupies 2,477 square miles of Minnesota and North Dakota. The subbasin includes all of the land which drains directly into the Red River main stem. Drainage areas at the confluence of the Main Stem and its tributaries are undifferentiated; hence, the Main Stem boundaries as defined (Figure I) are arbitrary delineations in the sense that part of the land in most of the other subbasins could be included in the Main Stem Subbasin.

Topographically, the subbasin is almost featureless--a fact directly related to recent geologic history. During the last glaciation, the entire subbasin was covered by the continental ice sheet. As the glaciers retreated northward, glacial meltwater was trapped north of present day Lake Traverse and formed a vast freshwater lake called Lake Agassiz. The successive stages of growth and retreat of Glacial Lake Agassiz formed beachridges or strandlines which clearly delineate the prehistoric extent of this vast lake. What is known today as the Red River Valley is actually the ancient lake plain bounded by the beach ridges of former Lake Agassiz. The Main Stem Subbasin is located in the center of the Red River Valley.

Fluvial and lacustrine sediments were deposited by glacial meltwater to form the flat bed of the subbasin. The Red River of the North is formed by the confluence of the Ottertail and Bois de Sioux Rivers at Wahpeton and Breckenridge. From there, the Red flows north for 395 miles before reaching the U.S.-Canadian border. Today, this fertile plain drains north at an average gradient of about one-half foot per mile. The slope of the Red River diminishes from 1.3 feet per mile at Wahpeton-Breckenridge to only about 0.2 foot per mile at the Canadian border. Channel widths of the river vary from 200 to 500 feet, and the average depths at bank-full stage range from 10 to 30 feet. The Red has no sharply defined valley, but only a shallow channel that is small relative to the river's vast drainage area.

The flatness of the subbasin, in combination with the northward flow of the river, are major physiographic elements that induce flood problems in the subbasin and in the entire Red River Drainage Basin as well.



Source: Gulf South Research Institute.

Figure I. MAIN STEM SUBBASIN

Broad natural levees that flank the river reach a height of five feet above the adjacent floodplain at Oslo, Minnesota. Once the natural levees are topped, broad areas may be inundated by rising flood waters. Floods in the Main Stem Subbasin are attributable to spring snowmelt, sometimes in combination with other compounding factors such as rainfall.

The tall grass and mixed grass prairie which once covered the Red River Valley area and the Main Stem region has been modified drastically by agricultural development. Today, 87 percent of the land area in the subbasin is cultivated. The agricultural economy of the Main Stem area is rich and diversified with crops such as wheat, barley, sunflowers, sugar beets, potatoes, corn, oats, and hay. Only 2.5 percent of the land area is pasture, and forests comprise another two percent of the total subbasin land area. The bottomland hardwood forests which survived agricultural land clearing operations are confined today to corridors along the Red River and its tributaries. Shelterbelts and windbreaks of exotic and native species are characteristic features of the agricultural landscape.

The subbasin contains a significant proportion of the population of the entire Red River Basin, a fact which partially accounts for the magnitude of flood damages sustained in this part of the study area. Seven percent of the subbasin land area is urban. The subbasin contains the three largest cities of the entire Red River Basin: Fargo (57,394), Grand Forks (42,959), and Moorhead (29,219). Other significant urban centers include East Grand Forks (8,909), Wahpeton (8,701), Breckenridge (3,829), Dilworth (2,360) and Drayton (1,103).

III. PROBLEMS, NEEDS, AND DESIRES

III. PROBLEMS, NEEDS, AND DESIRES

The primary water-related problems, needs, and desires in the Red River Basin are flood control, fish and wildlife conservation and enhancement, recreation, water supply, water quality, erosion control, irrigation, wastewater management, and hydropower. Various water-related problems, needs, and desires have been identified for the Main Stem Subbasin in previous planning reports on the basis of analysis of conditions and public and agency comments. The list of problems, needs, and desires for the subbasin is the same as the list for the Red River Basin as a whole. Each problem is discussed separately below, with an emphasis on flooding problems.

Flooding Problems

Nature of the Problems

Damaging floods from snowmelt, high intensity rains or a combination of both occur in the subbasin almost on an annual basis. Snowmelt floods result from snow accumulation over the winter months followed by rapid thaws in March, April and sometimes early May. Because summer storms are generally localized, they usually do not affect the Main Stem area nearly as much as other subbasins, however, the July 1975 storm was an exception.

As in other subbasins, however, two separate types of flooding occur: the most damaging type associated with river bank overflow (overbank flooding) and another type caused by runoff from snowmelt or heavy rainfall impounded by plugged culverts and ditches within sections of land bounded by roadways on earthen fill (overland flooding). In overland flooding, the trapped water slowly accumulates until it overflows the roadways and inundates section after section of land as it moves overland in the direction of the regional slope until reaching river or stream channels.

The northward flow of the Red River is a unique factor influencing the magnitude of Main Stem floods. Snowmelt begins in the south and advances to the north. Local and tributary runoff tends to synchronize with peak flood stages on the Main Stem. Floodwaters advancing from the south are sometimes blocked by ice and snow, which results in backwater flooding and localized increases in flood stages.

The topography of the subbasin, although almost featureless compared to other subbasins, nevertheless influences flooding in the area. The broad natural levees that flank the Red River attain a height of five feet above the adjacent valley plain at Oslo, Minnesota. When rising waters overtop or circumvent the levees, lands for several miles on either side of the river are usually flooded.

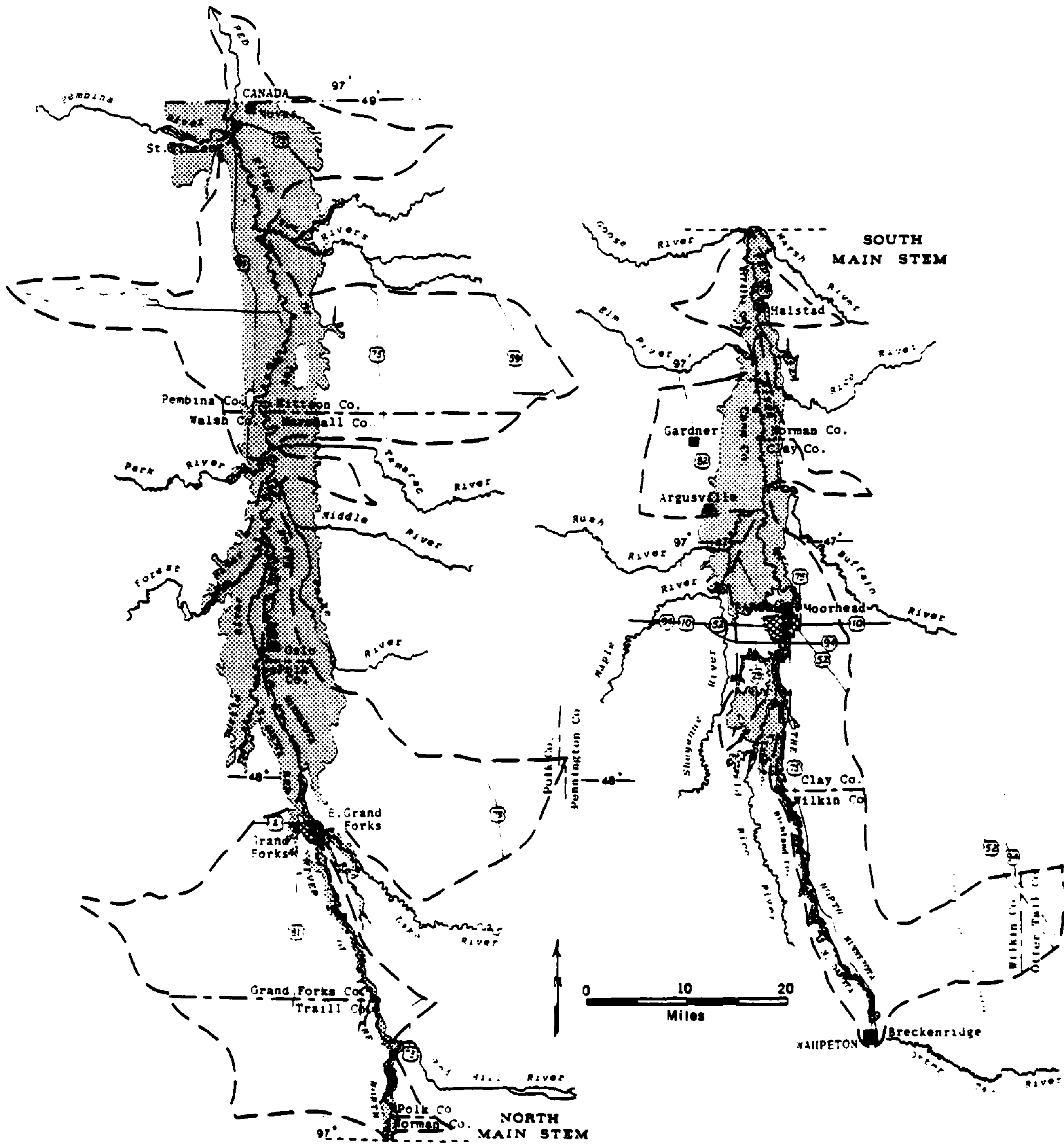
Increased runoff from both agricultural use and urban development also contributes to the flooding problem. Intensified development of agricultural land in the floodplain generally aggravates the existing drainage problem of sheet flow over extensive land areas that is, in part, a result of the flat terrain. Significant floodwater damage occurs to urban (particularly residential) development in the subbasin. Areas subject to flooding contain major portions of six cities and eight towns.

Location and Extent

Figure II depicts the 100-year floodplain for the Main Stem Subbasin. Unlike the other subbasins, a generalized floodplain map has been delineated and is available for general use. The Regional Floodplain Area of the Red River Main Stem published in the 1972 Souris-Red-Rainy River Basins' Red River Type II Study constitutes the basis for the delineation shown in Figure II.

USGS Flood Prone Area Maps and Corps of Engineer photomosaics of the 1979 flood also provide excellent coverage, especially when compared to that generally available for other subbasins. Thirty Flood Prone Area Maps provide a 100-year floodplain delineation along the entire course of the Main Stem, with most extensive coverage in the southern end. The 1979 photomosaics of the Red River and individual tributaries provide similar coverage, but tend to focus on the northern end of the subbasin. Both sources correlate well with Figure II.

The Red River Regional Floodplain Area of the Souris-Red-Rainy River Basins Type II Study is published as 12 plates at a scale of approximately one inch to 2.3 miles. Subbasin boundaries superimposed by the study team revealed that the approximate 600,000 acres of floodplain shown encompassed major and minor portions of 17 individual subbasins, including approximately 5,000 acres adjacent to the Canadian Border that is outside the study area.



Source: Gulf South Research Institute.

Figure II. 100-YEAR FLOODPLAIN

When these areas are subtracted out, approximately 460,000 acres are within the Main Stem Subbasin.

As shown in Figure II, the width of the Main Stem floodplain varies significantly along its course from south to north. With the exception of the area near the confluence of the Wild Rice River where the floodplain bulges to approximately six miles in width, the southern end below Fargo and Moorhead ranges from a quarter-mile to one mile in width. A roughly triangular floodplain area with a base approximately 14 miles in width extends from above the cities mentioned northward to the confluence with the Sand Hill River, where the width is about one-half mile.

A second area of constricted floodplain extends from the latter point northward to the vicinity of Grand Forks and East Grand Forks. The range for this segment is generally one-half to one mile in width. The second major segment of extensive floodplain extends from the cities cited above all the way to the U.S.-Canadian Border. It is important to note that the floodplain actually extends beyond the boundaries of the subbasin to both the east and the west along much of this segment, encompassing parts of the Turtle, Snake, Middle, Forest, Park, Tamarac, Two Rivers, and Pembina subbasins. Widths range from about 11 miles near Oslo, Minnesota, to nearly seven miles near Drayton, North Dakota and finally to 12 miles or more near the International Boundary.

Flood Damages

Recurrent flooding throughout much of the Red River Valley has inundated large acreages of rural areas and many urban developments. Extensive damages to such properties as farmsteads, transportation facilities, private residences, and businesses are sustained during each flood event. In addition, extensive flood damages accrue to the over one million acres of floodplain farmland currently under cultivation. The clearing of timber, intensive wetland drainage, fall tillage, conversion of grassland to cropland, and drainage ditches have contributed to continuing flood problems.

Present average annual flood damages are $9.4 million. In comparison to the other subbasins, this is a sizeable figure accounting for approximately 23 percent of the Red River of the North basinwide total. Average annual flood damages are divided into two basic classifications: urban and rural.

Urban damages include damages to residences, businesses (commercial and industrial) and public facilities (streets, utilities, sewers, etc.). Rural flood damage include damages to crops, other agricultural assets (fences, machinery, farm buildings, etc.), and transportation facilities. Urban damages account for 32 percent of the total average annual damages in the subbasin, and rural damages account for the remaining 68 percent.

Urban damages sustained during the 1975 flood event amounted to $6.4 million. The flood event of 1979 resulted in $17.5 million in urban damages. In comparison, average annual urban flood damages are estimated at $3.2 million. A more detailed breakdown of these urban flood damage figures appears in Table 1. Urban damages resulting from the flood event of 1975 include $3.2 million in residential damages, $2.6 million in damages to businesses, and $638,000 in public damages. Urban flood damages resulting from the 1979 flood event included $8.7 million in residential damages, $7.0 million in business related damages and $1.7 million in public damages. Estimated average annual urban flood damages include $1.6 million residential damages, $1.3 million in business damages, and $324,400 in public damages.

Table 1

MAIN STEM SUBBASIN, ESTIMATED 1975, 1979, AND AVERAGE ANNUAL URBAN DAMAGES (Thousands of 1979 Dollars)

Category	Year 1975	Year 1979	Average Annual
Residential	$3,190.1	$ 8,729.5	$1,622.1
Business	2,552.1	6,983.6	1,297.6
Public	638.0	1,745.9	324.4
Total	$6,380.2	$17,459.0	$3,244.1

Sources: Red River of the North Basin Plan of Study, April, 1977; Post Flood Reports, 1975, 1979; and Gulf South Research Institute.

Average annual rural flood damages along with the rural flood damages sustained in the flood events of 1975 and 1979 appear in Table 2.

Table 2

MAIN STEM SUBBASIN, ESTIMATED 1975, 1979, AND AVERAGE ANNUAL RURAL FLOOD DAMAGES (Thousands of 1979 Dollars)

Category	Year 1975	Year 1979	Average Annual
Crop	$26,161.0	$30,413.0	$4,636.7
Other Agricultural	8,935.6	10,755.0	1,545.6
Transportation	3,727.1	1,962.0	167.9
Total	$38,823.7	$43,130.0	$6,350.2

Sources: Red River of the North Basin Plan of Study, April, 1977; Post Flood Reports, 1975, 1979; and Gulf South Research Institute.

The 1975 flood event resulted in $26.2 million in crop damages, $8.9 million in other agricultural damages and $3.7 million in transportation damages. The flood event of 1979 resulted in $30.4 million in crop damages, $10.8 million in other agricultural damages, and $2.0 million in transportation damages. Total rural flood damages incurred in the flood events of 1975 and 1979 were $38.8 million and $43.1 million, respectively. Estimated average annual rural flood damages in the subbasin include $4.6 million in crop damages, $1.5 million in other agricultural damages and $167,900 in transportation damages. Total average annual rural flood damages are $6.4 million.

Environmental Concerns

Problems associated with wildlife in the Main Stem are similar to those previously described in the other reports prepared for tributary streams to the Red River of the North. They center primarily around the past and present loss of woodland, wetland, and native prairie habitats to agricultural, urban, and other forms of development. Within the Main Stem Subbasin, cropland, range and pasture, urban, and other land uses represent 98.6 percent (1,563,086 acres) of the total subbasin area (1,585,280 acres). Woodlands account for only 1.1 percent, or 17,438 acres, of this total along the 395 river miles from the Bois de Sioux-Ottertail rivers

confluence to the Canadian border. These woodlands occur primarily as a riparian community along the Red River and up the main tributary streams within the subbasin's confines, and as shelterbelts or windbreaks on farmsteads. In many places, the riparian communities are very narrow where agricultural or urban development has resulted in the removal of woodlands and brushy areas almost to the stream edge. The high fertility of the soils and lack of high-ground areas suitable for urban development have caused this encroachment. Planted shelterbelts and windbreaks may or may not afford quality habitats for wildlife, depending on factors such as plant species composition, areal extent, and location. The removal of the native woodlands in both bottomland and upland situations has been detrimental by decreasing both population densities and species diversity of wildlife within the Main Stem Subbasin. Therefore, there is a very apparent need to protect the remaining woodlands and enhance this valuable habitat for wildlife, wherever possible (Souris-Red-Rainy River Basins Commission, 1972; Soil Conservation Service, 1963; U.S. Army Corps of Engineers, 1978; U.S. Fish and Wildlife Service, 1979).

Development within the subbasin has also had a very pronounced detrimental impact on the native grasslands or prairie and wetlands which once flourished in the area. Nearly all of these major habitat types have been cultivated or drained and then converted to farmland or other land uses. Some remains of the native prairie ecosystem may be found in the range and pasture land use category (28,535 acres), or confined to locales such as purchased prairie remnants, fence rows, roadsides, shelterbelts, or other relatively undisturbed sites. Wetlands have been reduced generally to oxbows, farm ponds, and remnants owned by either the state game and fish agencies or the U.S. Fish and Wildlife Service (e.g., WMA's and WPA's). Threats currently facing non-protected wetlands include sedimentation from surrounding agricultural field erosion, channelization, and land use changes (U.S. Army Corps of Engineers, 1978; U.S. Fish and Wildlife Service, 1979).

Problems affecting aquatic biota are related to water quality degradation within the Red River proper and its tributaries. The Red River characteristically has prolonged periods of low flows, as well as flood flows. The U.S. Geological Survey (1979) indicated that the Fargo area had zero flows

for many days during the drought period of from 1932-1941 and had nine days of no flow in 1976. The lowest flows generally occur in fall but also in the winter, mainly as the result of winter freezing. The Red River receives appreciable amounts of industrial, municipal, and agricultural pollutants in the form of untreated or poorly treated effluents from point sources and runoff (pesticides, fertilizers, animal wastes) from nonpoint sources such as feedlots and agricultural fields. When these pollutants exceed the assimulative capacity of the river, such as during periods of low or no flow, water quality conditions (e.g., low dissolved oxygen concentration) are degraded to the point that fish kills take place and other aquatic life is destroyed. Problems also occur during the winter months during some years when winter ice and snow cover in combination with prolonged periods of low or neglible flow prevent reareation. Low dissolved oxygen levels develop, resulting in fish kills and destruction of other aquatic organisms. This situation may be compounded with the presence of pollutants from the sources described above (Minnesota Pollution Control Agency, 1975; Upper Mississippi River Basin Commission, 1977; Souris-Red-Rainy River Basins Commission, 1972; U.S. Fish and Wildlife Service, 1979).

Sedimentation is also a problem in the river as a result of water and wind erosion of the extensive farmland within the Main Stem Subbasin and in the tributary stream subbasins and from streambank erosion. Turbidity levels are unacceptable in many areas, and siltation of bottom substrates occurs, which reduces the productivity of aquatic habitats and effects the species composition of aquatic life in the Red River. Improvements in water quality are greatly needed in the subbasin to restore habitat quality for fishes and other aquatic organisms. It should be noted that although the fishery value of the Red River has decreased steadily because of the water quality degradation, it still has a critical value because of its good sport fishery (U.S. Army Corps of Engineers, 1978; Souris-Red-Rainy River Basins Commission, 1972; Minnesota Pollution Control Agency, 1975; U.S. Fish and Wildlife Service, 1979).

Recreation Problems

The major recreation problem in the subbasin is the distribution of water-based and related resources in relation to the population centers. The subbasin accounts for approximately 32 percent of the Red River Basin and supplies only 0.17 percent of the recreation water-based resources. The lack of large lakes and forests in the area has limited the recreation potential. In addition, the natural vegetative patterns have essentially restricted the growth of trees providing wildlife habitat to the immediate stream bank. There are, however, isolated wildlife management areas in the subbasin that provide hunting opportunities. Only two subbasins in the Red River Basin have less than the 1,091 acres contained in wildlife management areas in the Main Stem Subbasin.

The Red River, although providing localized fishing opportunities, is restricted in its fishing potential because of physical characteristics and poor water quality. Steep banks that limit accessibility, periods of low flow, and the unstable silty bottom are not conducive to good fishing. Poor water quality is the result of level fluctuations and municipal and domestic pollution. Municipal and industrial effluent discharge and septic tanks south of the Fargo-Moorhead area diminish recreational, biological, and aesthetic qualities of the river.

Most of the residents of the subbasin must travel to other areas in the Red River Basin to fulfill water-based or related recreation needs.

Water Quality Problems

The water quality problems of the Main Stem are a combination of natural and man-made effects. Insufficient streamflows during late summer and winter months do not normally meet the minimum requirements for waste assimilation. The Main Stem is classified as "undesirable" (500 mg/l TDS) by the North Dakota Public Health Service and the Minnesota State Water Quality Standards (Upper Mississippi River Basin Commission, 1977). Many non-point sources, especially agricultural operations, introduce nitrates and phosphates in excessive concentrations into the Red River. Wastewater treatment facilities, which will be discussed in a later section, create problems with very high fecal coliform populations. These pollutants reduce the river's productivity and impair many of its uses such as recreation,

stock watering, and fish and wildife propagation (North Dakota Public Health Service, 1978; Upper Mississippi River Basins Commission, 1977). Dissolved oxygen levels posed minor problems, except near the Bois-de-Sioux River where the percent violation of the standard (5.0 mg/l) was 22 (Minnesota Pollution Control Agency, 1975).

Groundwater supplies within the subbasin are generally characterized by excessive concentration of total dissolved solids (TDS), manganese, iron, and sulfates (Upper Mississippi River Basin Commission, 1977).

Water Supply Problems

The Red River's complex system of tributaries and reservoirs determine the quantity and quality of water available for the municipalities and industries of the subbasin. The water quality of the supplies is usually adequate, with the exception of excessive iron and/or manganese in Dilworth, Halstad, Karlstad, Kent, Oslo, Perley, Moorhead, and Rothsay, Minnesota. High dissolved solids and chlorides at Halstad and very high dissolved solids and sulfates at Kent are also problems.

Some communities which rely on surface water as a main supply have experienced water shortages during dry years when the river experiences low flows. This includes almost all of the major population centers in the subbasin. In some cases groundwater is used to supplement surface water. Cities with expected industrial and population growth, such as Moorhead, can be expected to have a heavy increase of water demands in the future. The city of Moorhead currently experiences problems of water hardness and odor, especially during the warm months of July and August when the river has a low flow and is moving slowly.

Erosion Problems

Soil erosion and sedimentation are considered problems along portions of the Red River. The most significant concern relating to sedimentation is during major flood overflows. Sediment deposited on the floodplain by floodwaters causes substantial delays in planting and adds to treatment costs for nuisance weeds. In conjunction with floodplain sedimentation, floodplain erosion in certain areas has scoured and removed rich topsoil, causing long-term reductions in soil fertility. Many small tributary ditches entering the Red River have erosion problems at their outlets, which contributes to the sedimentation and pollution of the river.

Upstream erosion of cropland, pastureland, woodlands, and streambanks is considered to be the principal source of sediment. Sand and water erosion is the limiting factor in crop production and adds to the sediment load of the tributary streams and Main Stem. Topsoil eroded by water is lost from croplands, and the inherent productivity of these lands is permanently reduced. Wind deposited soils cause increased maintenance costs for highway ditches and floodway and drainage channels. Another consequence of wind erosion is an unestimated amount of air and water pollution.

Irrigation

Only a small portion (less than 10,000 acres) of the subbasin's total land area is irrigated. The suitability of the soils for irrigation is closely associated with the glacial history of the Red River Basin. The soils derived from the fine-textured lake plain sediments are generally not irrigated because of the low permeability of the soil. The lake plain soils in North Dakota are considered unsuitable for irrigation because of poor surface drainage, slow permeability, and restricted internal drainage. Irrigation is practiced with more favorable results on the Minnesota side of the Red River. The silt deposits of the lake plain are irrigated on a limited basis by water from local supplies of impounded surface water, which is applied by sprinkler systems. Wells are also a source of irrigation. The primary crops which are irrigated include corn, alfalfa, potatoes, sugar beets. A few less important crops are also irrigated.

Wastewater Management

As was mentioned in the water quality section above, the coliform bacteria populations of the Red River exceed water quality standards much of the time. Inadequate waste treatment facilities such as those at Abercrombie, Fargo, Georgetown, Kent, and Moorhead contribute to excessive concentrations that lower the water quality. Fecal coliforms have been reported to be in violation of the standards from 17-78 percent of the time. High coliform populations exist consistently downstream of Fargo for an airline distance of about 30 miles and persist in spite of continued chlorination of sewage effluents at both the Fargo and Moorhead treatment plants. Sugar

beet processing plants located along the Main Stem also present problems (Minnesota Pollution Control Agency, 1975; Upper Mississippi River Basin Commission, 1977). Table 3 lists the wastewater treatment facilities of the subbasin and their problems and needs.

Hydropower

The U.S. Army Corps of Engineers' Institute for Water Resources has identified the dams on the Red River at Drayton and Fargo, North Dakota as potential hydropower sites. These dams are small-scale facilities which were built primarily for flood control and water supply purposes. Although these sites are considered to be potentially favorable to hydroelectric development, the flat topography and low streamflow conditions in the subbasin will severely limit future plans.

Public Perception of Problems and Solutions

The public's perception of problems and solutions in the subbasin is moderatly well defined. The Corps of Engineers has held several public meetings and has supported public involvement programs in the subbasin since 1976. There is no comprehensive watershed district for the subbasin, because the watershed boundaries are arbitrary as a result of undifferentiated drainage patterns associated with the main stem.

The primary documents for the identification of public perceptions are the Grand Forks and East Grand Forks Urban Water Resources Study of 1976 and its 1978 Floodplain Management Appendix. Other documents include the 1977 Corps of Engineers Plan of Study for the Red River of the North Basin and the Corps of Engineers Water Resources Planning and Development Report of October, 1979.

Public involvement programs conducted in conjunction with the Grand Forks-East Grand Forks Urban Water Resources Study beginning in 1976 and the Fargo-Moorhead Stage II Urban Study beginning in 1979 have served to identify major problems and solutions as perceived by the public. From these programs, the primary water related needs of the subbasin have been expressed as water supply, water quality, flood control, wastewater management, fish and wildlife conservation, erosion and sediment control, and water oriented recreation opportunities near metropolitan areas.

Table 3

WASTEWATER TREATMENT FACILITIES OF THE MAIN STEM SUBBASIN

Discharger	Type Treatment	Problems, Needs, or Comments
MINNESOTA		
Brechenridge	Primary and secondary ponds	No apparent problems
Rothsay	Trickling filter, settling tank, chlorination	Repairs until new facility is built
Wolverton	Aeration tanks, settling tank, chlorination	
Comstock	Primary and secondary ponds	Possible pond leakage
Moorehead Electric Plant	None	No treatment
American Oil Company	None	Nature of problems unknown
Moorhead	Activated sludge trickling filter, chlorination	No apparent problems
American Crystal Sugar	Two-pond retention system	Nature of problems unknown
Perley	Primary and secondary ponds	Excessive flow and TSS levels
Halstad	Secondary activated sludge	TSS levels too high
Nielsville	Primary and secondary ponds	No apparent problems
American Crystal Sugar at East Grand Forks	Three aerobic ponds, clarifier filters	Nature of problems unknown
East Grand Forks	Primary and secondary ponds	No apparent problems
Oslo	Primary and secondary ponds	Ponds may leak
Oslo Water Works	None	Provide treatment or connect to municipal system
Karlstad	Primary and secondary ponds	No apparent problems
Kennedy	Primary and secondary ponds	No apparent problems
NORTH DAKOTA		
Abercrombie	Primary and secondary ponds	Enlarge lagoon
Buxton	Primary and secondary ponds	Construct 22 acre lagoon
Christine	Primary and secondary ponds	Enlarge lagoon 0.5 acre
Drayton	Primary ponds	Approaching maximum design flow
Fairmount	Primary and secondary ponds	1.5 acre lagoon
Fargo	Mechanical plant	Update unit process
Gardner	Primary and secondary ponds	No apparent problems
Grand Forks	Mechanical plant	227-225-236 acre cells
Pembina	23 acre primary pond	Remodel existing lagoon
Reynolds	Primary and secondary ponds	Approaching maximum design flow
Thompson	Primary and secondary ponds	Construct new lagoon
Wahpeton	Aeration, primary and secondary ponds	Construct new 60 acre lagoon

Source: Minnesota Pollution Control Agency, 1975; Sheuman, no date; North Dakota State Department of Health, 1978.

In a 1978 public workshop, citizens of Grand Forks and East Grand Forks requested that riverfront beautification measures be incorporated with flood control work. The city also indicated a desire for formulation of an emergency plan of action to deal more effectively with flood emergencies in the absence of any permanent flood damage reduction measures.

Additional evidence for interest in flood control measures is contained in public hearings held in Grand Forks in 1978 and 1979 before subcommittees of the Committee on Public Works and Transportation of the U.S. House of Representatives. From these documents it is evident that most residents of the Red River Basin consider flood control to be the primary water related need for the area and that they are interested in whatever solutions may be proposed by Federal, state, or local agencies.

IV. DESCRIPTION OF SUBBASIN RESOURCES

IV. DESCRIPTION OF SUBBASIN RESOURCES

This section of the report discusses the primary resource conditions within the subbasin that are water-related and that would be affected by a comprehensive water and related land resources plan centering on flood control measures.

Social Characteristics

The population of the subbasin has steadily increased over the past several decades. This is due in part because agricultural employment has decreased due to farm consolidation and increased mechanization, and many people living in the rural parts of the subbasin and in surrounding subbasins have moved to the urban areas in search of better economic opportunities. Between 1970 and 1977, the subbasin's population increased from 166,072 to 177,361, which was a seven percent increase. The only counties within the subbasin that decreased in population during the 1970's were Norman and Wilkin, which are located in Minnesota in the southern part of the subbasin. Norman County experienced a natural decrease (more deaths than births) and had a net out-migration rate of -2.2 percent. Wilkin County's small natural increase (more births than deaths) was greatly offset by the net out-migration (-7.3 percent) which occurred. Four of the counties which increased (Kittson, Marshall, Clay, Grand Forks) in population had net out-migration, which ranges from -0.6 percent in Kittson County to -3.6 percent in Grand Forks County. The out-migration was offset by natural increases in each county, resulting in a total county population increase. The counties of Pembina, Walsh, Traill, Cass, and Richland in North Dakota and Polk County in Minnesota increased due to a combination of natural increase and net in-migration. The highest rate of net in-migration was in Cass County (six percent), and the lowest rate of in-migration was in Pembina County (less than 0.05 percent). The population density increased from 67.0 persons per square mile in 1970 to 71.6 persons per square mile in 1977. This is the most densely-populated subbasin in the Red River Basin.

The largest cities in the subbasin are Fargo (57,394) and Grand Forks (42,959) in North Dakota, and East Grand Forks (8,909) and Moorhead (29,219) in Minnesota. All of these cities increased in population between

1970 and 1977, except Moorhead, which decreased by 1.6 percent. The city of Wahpeton, North Dakota increased from 7,076 to 8,701 (23 percent increase) during the 1970's. Except for Drayton (1,103), North Dakota and Dilworth (2,360) and Breckenridge (3,829), Minnesota, there are no other towns in the subbasin with populations over 1,000.

Eleven counties in the subbasin have significant portions of their populations who are of Scandinavian background. Norway is the primary country of origin, ranging from 28 percent in Wilkin County to 69 percent in Norman County. Approximately 45 percent of the Kittson population is of Swedish background. Forty-five percent of the Pembina County population is of Canadian extraction. The minority population is too small to be identified.

There are 13 counties represented in the subbasin divided almost evenly between the two states, with seven in Minnesota and six in North Dakota. The is the only subbasin in the Red River Basin which is distinguished by the presence of large urban centers. The factors used to identify the degree of community cohesion, i.e., home ownership, length and county of residence, and county of employment, are clearly differentiated in the subbasin because of the urban centers. The three largest cities are located in Clay, Cass, and Grand Forks counties, which show significantly lower figures for home ownership and length of residence than the more rural counties in the subbasin. In Clay County, 68.1 percent of the population own their homes, with 59.3 percent in Cass County and 51 percent in Grand Forks County. In the remainder of the subbasin, home ownership statistics range from 71 percent in Richland County to 81.9 percent in Marshall County. In the urban counties, only 38 percent of the 1970 Grand Forks County residents and 48 percent of the Clay and Cass County populations occupied the same residence in 1965. The rural counties ranged from 61 percent in Kittson County to 71 percent in Walsh County occupying the same residence during the five-year period. The urban counties registered slightly more comparable figures for populations remaining within the same county, however, with 55 percent in Grand Forks County, 68 percent in Clay County, and 70 percent in Cass County. For populations residing in the same county, the more rural counties ranged

from 65 percent in Kittson County to 89 percent in Norman and Pembina counties. Most people in the subbasin work in the county of residence, with 10 counties in the 82 to 89.9 percent range. In the remaining counties, 75.8 percent of the Wilkin County population works and resides in the county, with 74 percent in Polk County and 60.5 percent in Clay County. It is likely that a significant number of Clay County residents work in the Fargo area in Cass County.

Economic Characteristics

Employment

Between 1950 and 1970, farm employment in the subbasin declined as a result of a move toward large-scale farm units and increased mechanization. Employment in other sectors increased, especially in the central portion of the subbasin in the urban centers of Grand Forks-East Grand Forks and Fargo-Moorhead. The result was an overall increase in total employment between 1960 and 1977. The trade and services sectors have grown substantially, and in the Grand Forks area, government employment has increased. This is because of the presence of Grand Forks Air Force Base. Although agricultural employment has decreased, it is still the most important sector in the subbasin's economy. Between 1970 and 1977, total employment in the subbasin increased from 61,447 to 83,360, which was a 35 percent increase. The more rural parts of the subbasin depend on Grand Forks and Fargo not only for various job opportunities, but also for the services they provide. The city of Grand Forks has a trade area that includes the northeast part of North Dakota as well as the northwest portion of Minnesota. Fargo serves the southern part of the subbasin itself as well as surrounding subbasins. Unemployment in the subbasin averaged about 6.5 percent during the 1970's. In the rural areas of the subbasin, employment is high during the growing and harvesting season and low during the winter when agricultural activities decrease.

Income

Total personal income for the subbasin increased from $1,017 million to $1,367 million between 1969 and 1977 (as expressed in 1979 dollars).

Farm income accounts for more than 60 percent of the total personal income, and cash grain sales amount to almost three-fourths of the total farm income. Average per capita income during the same years increased from $6,121 to $7,709, which was 11 percent higher than the 1979 average income figure for North Dakota and slightly more than seven percent lower than Minnesota's 1979 average income.

Business and Industrial Activity

Agriculture

Agriculture is the main economic base for the subbasin, and the most important agricultural product is small grains. Approximately 90 percent (or 1,426,752 acres) of the subbasin's land area is under cultivation, and two percent is pasture. Livestock production is important in the southern half of the subbasin.

The major crops grown in the subbasin are identified in Table 4. Wheat is the leading crop, accounting for 41 percent of the harvested acreage. This is followed by barley and sunflowers, which amount to 21 percent and 14 percent, respectively, of the harvested acreage. Other important crops in the subbasin include hay, sugar beets, oats, potatoes, and corn, which collectively account for 21 percent of the harvested acreage. There are also minor acreages of flax, rye, and soybeans. The production of sunflowers has increased greatly during the 1970's, and it has become a leading crop in this subbasin as well as throughout the Red River Basin.

Table 4

1978 CROP STATISTICS, MAIN STEM SUBBASIN

Crop	Harvested Acres	Yield Per Acre	Total Production
Wheat	469,100	35.9 bushels	16,840,690
Barley	245,260	50.8 bushels	12,459,208
Sunflowers	158,400	1,515 pounds	239,976,000

Source: Gulf South Research Institute.

Most of the subbasin is characterized by level, heavy-textured soils. This subbasin has the most productive soils in the Red River Basin. Most of the subbasin is devoted to growing small grains, sunflowers, potatoes, soybeans, and sugar beets. The floodplain is a very important agricultural area, and most of it is already under cultivation. Although wheat and barley remain the principal crops, in recent years the Red River Valley has become an important area for the production of potatoes, sugar beets, and sunflowers.

Manufacturing

There are 262 manufacturing establishments in the subbasin, 194 of which are located in the Fargo-Moorhead and Grand Forks-East Grand Forks areas. Most of the establishments are related to agriculture, but there is also a high degree of diversification. In contrast to most of the other subbasins, there are many medium and large-scale employers. Manufacturing employment amounts to about 12 percent of the subbasin's total employment. The manufacturing establishments are combined in Table 5 and grouped according to their Standard Industrial Code (SIC) numbers. The estimated number of people employed by manufacturing establishments in the subbasin is also given.

Trade

In 1977, total trade receipts for the subbasin exceeded $1,787 million (expressed in 1979 dollars). More than 65 percent (or $1,164.3 million) of the receipts were wholesale trade. Retail trade and selected service receipts were $623.6 million and $68.4 million, respectively in 1977.

Transportation Network

The major north-to-south highways in the subbasin include Interstate 29 and U.S. 75. U.S. 75 is located in Minnesota and generally parallels the Red River of the North the entire length of the state. I-29 parallels the same river, beginning at the United States-Canadian border in Pembina County and running south through the major cities of Grand Forks and Fargo. It travels the length of the Red River Basin in North Dakota, providing service to the subbasins west of the Main Stem into the urban centers. U.S. 75

Table 5

MANUFACTURING ESTABLISHMENTS, MAIN STEM SUBBASIN

SIC	Description	Estimated Employment
02	Agricultural Production-Livestock	10
13	Oil and Gas Extraction	20
14	Mining of Nonmetallic Minerals	60
17	Construction-Special Trade Contractors	130
20	Food and Kindred Products	3,750
22	Textile Mill Products	25
23	Apparel Made from Fabrics	835
24	Lumber and Wood Products	370
25	Furniture and Fixtures	10
26	Paper and Allied Products	50
27	Printing and Publishing	800
28	Chemicals and Allied Products	225
30	Rubber and Plastics Products	120
32	Stone, Clay, Glass, and Concrete Products	680
34	Fabricated Metal Products	925
35	Machinery, except electrical	680
36	Electrical and Electronic Machinery	70
37	Transportation Equipment	220
38	Measuring, Analyzing and Controlling Equipment	30
39	Miscellaneous Manufacturing Industries	55
42	Motor Freight Transportation/Warehousing	70
50	Wholesale Trade-Durable Goods	45
51	Wholesale Trade-Nondurable Goods	325
54	Food Stores	85
59	Miscellaneous Retail	45
73	Business Services	75
76	Miscellaneous Repair Services	75
TOTAL		9,785

Source: 1978-1979 Directory of North Dakota Manufacturing.

provides a similar service to the subbasins located in Minnesota. The major east-to-west highways are Federal Highway 2, which crosses the Red River at Grand Forks; U.S. 10, which runs from Minnesota to the Fargo-Moorhead area, and I-94, which runs between Minneapolis-St. Paul, through Fargo, and crosses the state of North Dakota.

The Burlington Northern Railroad has rail service throughout the subbasin, connecting the more rural areas to the cities of Grand Forks and Fargo. The Soo Line Railroad has an east-to-west rail line which crosses the Red River at Oslo, and the Chicago, Milwaukee, St. Paul and Pacific Railroad runs from Fargo south into the northeastern part of South Dakota and then into Minnesota.

The largest airports in the subbasin are located in the cities of Grand Forks and Fargo. Both of these airports offer commercial air service and have additional facilities such as terminals, hangers, parking, concrete runways, and snow removal capabilities. There are small airports with limited facilities located in Wahpeton, Breckenridge, and Karlstad.

A petroleum product pipeline that generally follows the route of I-94 passes through Fargo. Another one runs through Cass and Traill counties to its termination at Grand Forks. A pipeline carrying refined petroleum runs from the Kansas-Oklahoma area to a terminal in Grand Forks. A crude oil pipeline beginning in Northern Montana crosses the subbasin in Grand Forks County and terminates in Clearbrook, Minnesota. A crude oil pipeline crosses the subbasin north of Drayton. A short refined oil pipeline also runs from Grand Forks to the Grand Forks Air Force Base. A natural gas pipeline operated by Midwestern Gas Transmission Company brings natural gas to the Fargo-Moorhead area. The Grand Forks-East Grand Forks area is served by the Trans-Canada Pipelines Limited from Emerson, Manitoba, Canada.

Land Use

The principal land use in the subbasin is agriculture, with 90 percent of the land area under cultivation, and two percent in pasture. Except for the urban centers of Grand Forks and Fargo, most of the towns are very small. Urban development amounts to 4.5 percent of the total land area.

The major body of water is the Red River of the North, which in combination with its tributaries accounts for only 0.4 percent of the land area in the subbasin. About 1.5 percent of the land is forest, which is found primarily along the river.

Land use in the floodplain of the Red River of the North is about the same as land use in the subbasin. The floodplain is mainly under cultivation, and the small amount of forest acreage is located there.

Agricultural production has increased as a result of intensive ditching, wetland drainage, deforestation, and the utilization of marginally productive land.

Environmental Characteristics

Climate

The Main Stem Subbasin is characterized by wide variations in temperature, light to moderate precipitation, plentiful sunshine, and nearly continuous air movements. Temperature variations are caused when cool dry air from the north and warm humid air from the south move quickly into the area. The precipitation pattern is extremely varied, but generally increases from west to east. Average annual precipitation ranges from about 22 inches in the southeast to 19 inches in the northwest. Most of the precipitation occurs May through August, while the driest months are usually December, January and February. Mean annual temperatures for various locations along the Main Stem are Pembina, North Dakota, -37.8°F, Fargo, North Dakota, -40.7°F, and Wahpeton, North Dakota, -42.8°F. Frost free days along the Main Stem range from 115 days near the Pembina Subbasin to 130 days near the Buffalo Subbasin. Spring snowmelt, sometimes aggravated by rainfall, causes serious flooding along the Main Stem.

Geology

The basin lies within the Western Lake Section of the Central Lowland Province in the Interior Plains. The Interior Plains extend from the Arctic coast to the Atlantic and Gulf Coastal Plains and separate the Western Cordillera from the Canadian Shield and Appalachian Highlands. Together with the Canadian Shield, the Interior Plains form the stable

craton of the North American continent. The Western Lake Section is a young glacial plain characterized by a level lake plain bordered by morainic hills and outwash terraces. Bedrock and glacial geology have determined the surficial landforms present in the subbasin and Red River of the North Basin.

Bedrock in the subbasin is composed of a series of westward-dipping sedimentary rocks that are overlapped by undifferentiated Precambrian igneous and metamorphic rock at the Minnesota-North Dakota border. The sedimentary rocks are thin to the east in the northern part of the subbasin and are overlain by glacial lake deposits. Clay and silt lake deposits overlain by glacial till rest directly on Precambrian rocks in the southern part of the subbasin. stem. Alluvial deposits of the Holocene age are found in the floodplain of the Red River of the North and its tributaries, insofar as they lie within the subbasin.

Glacial geology has had the most profound effect upon the surficial characteristics of the subbasin. Glaciers are ice masses formed by the recrystallization of snow that move under the influence of gravity. During the most recent glacial period, an ice sheet moved through the more easily eroded sedimentary rocks. As it met resistance from igneous and metamorphic material, it carved the former Lake Agassiz basin.

At least four continental glaciers emanating from central Canada during the Pleistocene Epoch (beginning three million years ago and ending 100,000 years ago) spread southward during periods of high precipitation and cool summers. The advance, subsequent recession, and pattern of deposition of Pleistocene glaciers, particularly of the Wisconsin stage, are primarily responsible for the present landscape of the basin.

Glacial till is a heterogeneous mixture of clay, silt, sand, and gravels and was deposited directly by ice. The sediments are generally unstratified and may vary in size from very small particles to large boulders. Moraines, composed of till deposited as the glacier retreated, mark the lateral and forward extent of the glacier. The moraine near Lake Traverse trapped the meltwaters and formed Lake Agassiz, which, at it greatest extent, was 700 miles long and 700 feet deep at the northern ice border.

Fine materials that were washed from the glacier settled over till in the lake bed and eventually formed the present-day clay soils in the Red River Valley. The Red River and its tributaries cut into the lacustrine deposits to drain glacial meltwaters from the surrounding plains; however, new drainage patterns were less well developed than those existing in the preglacial period because of the flat terrain left by glacial processes.

The geologic parent material in which soils formed, climatic conditions, the weathering process, and time have combined to produce the fertile agricultural soils of the region. The level topography is conducive to agricultural development; however, the drainage pattern and flat land contribute to extensive flooding in the subbasin.

In the effort to resolve flooding problems in the Red River Valley, the area's slope instability should be considered in engineering designs. The weak, nearly saturated, highly plastic clay soils are subject to movement when loaded by structures or unloaded through excavation or erosion. These problems can be compensated for with proper engineering design.

Biology

Wanek (1967) described the native gallery forests of the Red River of the North from its headwaters at the confluence of the Bois de Sioux and Ottertail rivers to its lower reach at the U.S.-Canada border. The description of the woodlands of the Main Stem Subbasin provided below were derived from his investigation.

Three major overlapping forest communities are found within the Red River Valley--the elm-boxelder community, basswood-hackberry community, and oak-ash community. The elm-boxelder community occupies the wet floodplain along the river and the lower portion of the mesic slopes. In addition to the two dominant species, American elm and boxelder, subordinants include peach-leaved willow and cottonwood, which are situated primarily at the river's edge. In some areas, large cottonwoods will occur away from the river adjacent to an abandoned river channel. Trees from the other two communities may also be found in the floodplain and include ironwood, hackberry, green ash, basswood, and bur oak on the drier sites.

The shrub layer is composed of reproduction of the dominant tree species and some of its associates and species such as wild grape, Missouri gooseberry, Virginia creeper, and chokecherry. Flooding affects the abundance of the herbaceous layer, as well as the shrub and tree strata. Silting and inundation may cause high sapling mortality, and tree density is usually low, with high dominance values expressed through the large average size of the trees. The ground cover is dominated by wood nettle.

The basswood-hackberry community is located on the mesic slopes between the floodplain and the upland areas. The best representation of this community occurs in the Grand Forks region, where the most pronounced slopes occur. Basswood and hackberry are the dominant tree species, but slippery elm and ironwood are common. This community will also contain representative trees of the other two communities. The shrub layer consists of wild plum, round-leaved hawthorn, chokecherry, gray dogwood, hazelnut, nannyberry, and prickly ash, in addition to overstory reproduction. The herbaceous layer is comprised of species such as baneberry, columbine, sweet cicely, bloodroot, wild spikenard, wake-robin, and bellwort. The two dominants, basswood and hackberry, and boxelder decreased in abundance toward the north because of the severity of the climate. Grazing and cutting are the principal disturbance factors. Grazing causes tree density decreases and increases in average tree size, with the end result of declining total dominance. Recovery occurs rapidly when livestock are removed. Past cutting increases tree density but lowers average tree size and total dominance. The basswood-hackberry community is maintaining itself and exhibits slight encroachment into upland areas where it has been allowed by man.

The oak-ash community occupies the drier upland areas, reaching its greatest areal extent in the southern reaches where there is a greater abundance of uplands, but agricultural development has limited the community in some areas. Bur oak and green ash are dominant, with trembling aspen a common associate on the northern end of the subbasin. Shrubs include buckthorn, leadplain, gooseberry, wild rose, Juneberry, and round-leaved hawthorn. Herbaceous species from the surrounding grasslands occur in

this community and include prairie forbs such as cone-flower, goats's-beard, yarrow and white sage and grasses such as Kentucky bluegrass. Grazing and cutting are also primary disturbance factors.

As indicated in the Problems and Needs discussion, most of the native prairie has been converted to cropland, except in scattered, isolated areas. The dominant plants in the tallgrass prairie remnants include big bluestem, switch grass, Indian grass, and prairie dropseed. Midgrasses such as Kentucky bluegrass, little bluestem, and slender wheatgrass are frequent associates, as are forbs like yellow stargrass, Canada anemone, goldenrod, smallflower aster, prairie dandelion, and rattlesnake root (Stewart, 1975).

The majority of the wetlands in the Main Stem Subbasin have been drained and converted to farmland. As pointed out earlier in the Problems and Needs section, they have been reduced to oxbows, farm ponds, a few scattered marshes, and remnants owned by state and Federal agencies in wildlife production areas. Wetland types reported in the counties included by the subbasin in the 1964 wetland inventory in North Dakota and the 1964 and 1974 wetland inventories in Minnesota include the following: Type 1--seasonally flooded basins and flats, Type 3--shallow fresh marshes, Type 4--deep fresh marshes, Type 5--open fresh water, Type 6--shrub swamps, Type 7--wooded swamps, Type 10--inland saline marshes, and stockponds (U.S. Fish and Wildlife Service, 1979, 1980). The principal wetland types within the subbasin include types 1, 3, 4, 5, and stock ponds.

Important wildlife habitats in the subbasin are the remaining woodlands, wetlands, and grasslands. The woodlands and brushy areas provide den and nesting sites, territories, winter and escape cover, and winter food for many resident and migratory species in the region. They also furnish a travel corridor for animals moving north and south along the Red River. Forests afford breeding and nesting areas for birds and rank second only to wetlands in breeding bird populations, with 336.0 pairs/Km^2. They also provide an important ecotone or "edge" with adjacent habitats such as grasslands, agricultural lands, and aquatic habitats, and in such cases, will contain wildlife representative of the other bordering habitats.

Woodlands contain a greater variety of wildlife species than any other major habitat type found in the subbasin. Wetlands furnish breeding, nesting, feeding, and resting areas for waterfowl; breeding and rearing habitat for big and small game, furbearers, and other wildlife such as wading and passerine birds; spawning and nursery areas for fishes and aquatic invertebrates; and a high-yield food source for many resident species. They rank first in breeding bird densities, with 337.0 pairs/Km^2. The native grasslands or prairie, when found in combination with wetland complexes, form a dynamic and diverse ecosystem which supports diverse and abundant populations of birds, mammals, invertebrates and plants. Average breeding bird densities of 142.7 pairs/Km^2 have been recorded in this highly productive community. Because of their importance as habitats for wildlife and the limited areal extent of these communities within the subbasin, there is a need to protect, conserve, and enhance these areas wherever possible (U.S. Fish and Wildlife Service, 1979, 1980).

The white-tailed deer is the major big-game animal in the subbasin. Population densities along the Red River, at least on the North Dakota side, are high at >1.5 deer/square mile. Moose will occur but are generally confined to the northern reaches along the U.S.-Canada border. They are most common further east of the Main Stem in Minnesota and further west in North Dakota, particularly in the Pembina Hills-Turtle Mountains region. Black bear may also be found in the northern section, but are not considered common within the subbasin's boundaries. Small game mammals include the jack rabbit, cottontail, and tree squirrels. Waterfowl production is low (<4.0 breeding pairs/square mile) throughout most of the Main Stem because of past and present conversion of wetlands to cropland. The most common breeding species are the mallard, blue-winged teal, pintail, gadwall, wood duck, and northern shoveler (data from North Dakota Game and Fish Department in U.S. Fish and Wildlife Service, 1978; U.S. Fish and Wildlife Service, 1980).

The Hungarian partridge is the principal upland game bird, with moderate population densities (12-31 birds/1,000 miles of rural mail carrier route) in Grand Forks and Traill counties in North Dakota; populations are low

(<12 birds/1,000 miles) in the rest of the North Dakota portion of the subbasin. In Minnesota, densities are 20 birds/100 miles throughout the length of the subbasin. Sharp-tailed grouse populations are considered low (>3.0 sharptails/square mile) throughout the Main Stem on the North Dakota side; these birds are generally found in the extreme northern section of the Minnesota portion, with densities of 1-3 adult males/square mile. Pheasants occur all along the North Dakota portion, where densities are low (<1.0 hen/square mile) in the north, moderate (1.0-10.0 hens/square mile) in the middle section, and high (>10.0 hens/square mile) in the south. The principal pheasant range in Minnesota begins in southern Polk County and extends to the south, where densities of <5 birds/100 miles are reported. Furbearers include the beaver, mink, muskrat, raccoon, and red fox. Beaver populations are relatively low in the Main Stem as compared to those in subbasins in northwestern Minnesota. Muskrat and mink are considered common, as are the raccoon and red fox. Densities of red fox along the Red River in North Dakota range from 5.0-8.9 families/township (data from North Dakota Game and Fish Department in U.S. Fish and Wildlife Service, 1979: U.S. Fish and Wildlife Service 1980; Mann, 1979).

On the Minnesota side of the Main Stem, a total of 101 (Region 1N) and 103 (Region 1S) species of breeding birds have been reported from the two regions established by the Minnesota Department of Natural Resources that include the subbasin. Region 1N takes in the area from Norman County northward, and Region 1S encompasses the remaining southern portion of the subbasin. Species distribution within each region is as follows: Region 1N--three species of non-native pest birds, one species of non-native game birds, 10 species of native game birds, and 87 species of native nongame birds, Region 1S--three species of non-native pest birds, two species of non-native game birds, 15 species of native game birds, and 83 species of native nongame birds. In the northeastern region of North Dakota, which includes Pembina, Walsh, and Grand Forks counties along the Main Stem, approximately 273 species of avians have been reported, of which 168 species were identified as breeding birds. These counties would fall within both the Agassiz Lake Plain Region and the Prairie Pothole Region in the state. More specifically, a total of 113 species

of breeding birds have been reported from the Agassiz Lake Plain Region, which includes all of the Main Stem Subbasin. Based on relative abundance, there are six primary species considered common or abundant, 29 secondary species that are generally fairly common, and 78 tertiary species which are uncommon and rare. Typical breeding species in various habitats of the subbasin include the horned lark in croplands, bobolink in grasslands, morning dove in shelterbelts, red-winged blackbird in wetlands, and great horned owl in the forest community (Henderson, 1978; Stewart, 1975; Willis, 1977).

Thirty species of nongame mammals have been identified within the Minnesota counties bordering the Red River Main Stem. All of these animals, plus an additional nine species, have been reported from Main Stem counties in North Dakota or in the subbasins of tributary streams to the Red River. Sspecies in the tributary areas have ranges that extend into the Main Stem Subbasin and, in most cases, into the Minnesota area, as well. Fairly common to common nongame mammals include the masked shrew in moist areas; silver-haired bat in woodlands; thirteen-lined ground squirrel in grasslands and croplands; Gapper's red-backed vole in woodlands; meadow vole in grasslands, croplands, and woodlands; and meadow jumping mouse in woodlands, grasslands, and croplands (Henderson and Reitter, 1979a and b; Willis, 1977; Wiehe and Cassel, 1977; Burt and Grossenheider, 1976).

Eleven species of amphibians and eight species of reptiles have been reported from the Main Stem counties or in tributary stream subbasins, which could possibly occur in the Main Stem Subbasin. The one species which does not occur in both Minnesota and North Dakota is the Woodhouse's toad; this bufonid extends into Richland County in southeastern North Dakota but is considered rare in the eastern part of the state. The more common species of herpetofauna in the Main Stem Subbasin include the tiger salamander in wetlands, croplands, and grasslands; chorus frog in woodlands, wetlands, croplands, and grasslands; painted turtle in lakes and streams; and plains garter snake in woodlands, wetlands, croplands, and grasslands (Conant, 1975; Henderson, 1979a and b; Wiehe and Cassel, 1977; Willis, 1977).

From its origin at the confluence of the Ottertail and Bois de Sioux rivers to the Canadian border, the Red River of the North drains an area greater than 40,000 square miles. Some of the major tributaries include the Sheyenne, Wild Rice-Marsh, Red Lake, Goose, Forest, Pembina, and Roseau rivers. Much of the Main Stem and its tributaries have been channelized, which resulted in water quality degradation. Municipal and industrial effluent and agricultural and feedlot runoff contribute further to the degradation of the river's water quality.

The Red River is classified by the North Dakota Game and Fish Department (1978) as a Class I stream. This class stream is considered to have the highest valued fishery resource. The Minnesota Department of Natural Resources classifies the Red River as a warmwater game fish (Class II) stream. The justifications for both of these critical ratings is that the Red River provides a good sport fishery of walleye, northern pike, sauger, crappie, yellow perch, and especially channel catfish. The river also provides the municipal water supply for several communities. In contrast, the Souris-Red-Rainy River Basins Commission (1972) describes the fishery resources of the Red River as being historically and presently poor due to the extreme fluctuations in flow, the steep banks, and the constant siltation of the bottom substrate. Also, the poor water quality aids in reducing the productivity of the river. Walleye and northern pike populations on the Red River are described as being limited due primarily to the lack of habitat required for spawning (U.S. Army Corps of Engineers, 1978).

Other game fish, besides the few previously mentioned, that are present in the Red River include muskellunge, largemouth and smallmouth bass, pumpkinseed, white bass, rock bass, bluegill and other sunfish. Common rough and forage fish include longnose gar, goldfish, carp, river shiner, common shiner, fathead minnow, creek chub, common white sucker, redhorses, burbot, brook stickleback, Johnny darter, and freshwater drum. A total of 84 fish species have been reported from the Red River (U.S. Fish and Wildlife Service, 1979).

Cvancara (1970) reported 10 mussel species from the Red River. Two of these, *Strophitus rugosus* and *Proptera alata*, were represented by empty shells only. The other eight species were represented by at least one live specimen: *Fusconaia flava*, *Amblema costata*, *Quadrula quadrula*, *Lasmigona complanta*, *Anodonta grandis*, *Ligumia recta latissima*, *Lampsilis siliquoidea*, and *Lampsilis ventricosa*.

Water Supply

Domestic and industrial water supplies are obtained from both surface and groundwater sources throughout the subbasin. The bulk of the municipal and industrial water requirements of the Red River Basin are along the Main Stem at Wahpeton-Breckenridge, Fargo-Moorhead, Grand Forks-East Grand Forks, and Drayton. The present annual water usage rates of the major cities in the subbasin and their source of supply are presented in the following table.

Major Cities	Water Supply Source	Annual Usage/Gallons
Breckenridge, MN	Ground and Surface	200,750,000
Dilworth, MN	Ground	54,750,000
Moorhead, MN	Ground and Surface	1,460,000,000
East Grand Forks, MN	Surface	547,500,000
Fargo, ND	Surface	5,146,500,000
Grand Forks, ND	Surface	3,650,000,000
Wahpeton, ND	Ground and Surface	365,000,000
Drayton, ND	Surface	91,250,000

Source: Minnesota State Department of Health; North Dakota State Department of Health.

The water quality of the supplies is usually adequate, with the exception of iron and manganese in several supplies and high levels of sulfates, chlorides, and dissolved solids in other supplies. Fargo, Grand Forks, and Drayton experience water shortages during dry years since they depend on surface water as a supply. Grand Forks depends not only on the Red River as a source, but also the Red Lake River.

The city of Moorhead relies on the Red River of the North and also on five ground wells, one of which is a standby. The groundwater is obtained from two separate aquifers and is extremely hard, just like the surface water. A malting plant located at Moorhead utilizes a great percentage of the water supply.

Water Quality

The water quality in this subbasin has been severely degraded by municipal and industrial discharges and agricultural runoff. Fecal coliform concentrations appear to be the most persistent problems of the Main Stem. The coliform bacteria populations exceed the accepted standards (200 col/100 ml) from 17-78 percent of the time (see Table 6). Low streamflows during the late summer and winter months further degrade the water by concentrating these bacteria and ultimately reducing the dissolved oxygen levels. Turbidity levels are also increased because of the low flows. Excessive turbidity levels occur about 40-50 percent of the time along the Main Stem. Agricultural operations such as farmlands and feedlots contribute additional phosphorus and nitrogen concentrations into the Red River, which occasionally create potential problems (Upper Mississippi River Basin Commission, 1977; Minnesota Pollution Control Agency, 1975). Table 7 presents the water quality data from five stations along the Red River. Although the Upper Mississippi River Basin Commission (1977) reported excessive TSS concentrations, the Minnesota Pollution Control Agency (1975) and the U.S. Geological Survey (1979) show few or no problems associated with this parameter (tables 6 and 7, respectively).

The groundwater quality of the subbasin is given in Table 8. Total dissolved solids present problems throughout most of the subbasin. Sulfates and manganese are also occasionally excessive. The Upper Mississippi River Basin Commission (1977) reported excessive iron concentration within the subbasin. The data presented in Table 8 show that the iron levels are generally not in extreme concentrations.

Aesthetics

The lack of natural or artificial lakes and large wooded areas limit the aesthetic quality of the subbasin. Even though the subbasin is extensively

Table 6

SURFACE WATER QUALITY DATA AND VIOLATION IN THE MAIN STEM SUBBASIN

Description	Flow (cfs)	Temperature (°F)		D.O. (mg/l)		BOD5 (mg/l)		NH3 (mg/l)		Fecal Coliforms (MPN/100 ml)		TDS (mg/l)		pH		Turbidity (JTU)		Oil (mg/l)		NO3 (mg/l)		Phosphorus (mg/l)		TSS (mg/l)	
Water Quality Standards in this Segment		5 Max. Change Max: 2B-86 2C-90		2B 2C				2B 1.0 2C 1.5		200		700		6.5-9.0		25		2B 0.5 2C 10		1C 45					
Monitoring Stations	Average 7 Day 10 Year Low	Average Maximum	Percent of Violation	Average Minimum	Percent of Violation	Average Maximum	Percent of Violation	Average Maximum	Percent of Violation	Average Maximum	Percent of Violation	Average Maximum	Percent of Violation	Average Range	Percent of Violation	Average Maximum	Percent of Violation	Average Maximum	Percent of Violation	Average Maximum	Percent of Violation	Average Maximum	Percent of Violation	Average Maximum	Percent Violation
Red River of the North: RE-547		56		9.0		5.8		0.09		250				7.9		40						0.23		61	
Bridge on SH-210, headwaters	56		0		22				0		17	--		7.1-	0		50			--					
10 reports 1962-66		80		3.5		8.9		0.16		500				8.6		110						0.18		180	
Red River of the North: RE-452		56		9.9		1.1		0.15		1,996		249		8.1		31				0.25		0.25		69	
Bridge on 1st St. Moorhead,			0		0				0		55		0	7.6-	1		45				0				
Mn. 11 reports, 1971-1974		82		6.1		5.5		0.58		49,000		-		9.2		170				2.7		0.98		320	
RE-403		57		8.6		4.6		0.41		1,633		473		7.9		54		0.3		0.6		0.51		135	
Bridge on CSAH-19 nr. Perley	-		0		4				9		57			7.1-	0		64		0		0				
67 reports 1970-76		82		3.9		11		1.7		13,000		-		9.0		300		0.1		3.7		1.9		870	
RE-358		56		8.1		4.5		0.16		1,211				7.8		125						0.18		156	
Bridge on CAR-9 nr. Shelly	-		0		0		-		0		78	-		7.1-	0		82	-	-	--	-				
12 reports 1963-65		80		4.5		7.5		0.53		3,100				8.6		500						0.48		440	
Red River of the North: RE-6		56		8.4		4.7						359		7.9		100				0.80		0.27		102	
E. Grand Forks	-		0		6			-		-			0	6.8-	0		67		-		0				
33 reports 1956-69		80		4.6		12.0						--		8.7		1,100				0.87		0.37		400	
Red River of the North: RE-300		51		8.7		3.2		0.25		102		421		8.0		36		0.3		0.45		0.36		66	
E. Grand Forks			0		8				0		45		-	7.4	0		26				0				
48 reports 1970-76		80		0.2		8.7		1.5		1,100		--		8.8		160		0.3		2.7		0.83		410	
RE-276		49		8.8		3.0		0.36		1,352		294		7.9		32		0.3		0.63		0.29		75	
Bridge SH-1 at Oslo			0		2				2		67		0	7.2-	0		58		0		0				
65 reports 1970-76		77		4.7		6.7		7.1		13,000		--		8.7		120		0.3		15		0.59		290	
RE-206		57		8.4		3.8		0.08		522				7.8		97						0.28		164	
Bridge on SH-11 nr. Robbin	-		0		7				0		44	--	-	7.2-			71			--	-		-		
15 reports 1962-65		78		4.6		6.3		0.3		1,300				8.8		280						0.47		480	
RE-155		49		9.4		2.6		0.19		167		374		7.9		67		0.3		0.81		0.29		102	
Emerson, Manitoba			0		0		0		0		19		--	6.8-	0		63		0		0				-
48 reports 1970-76		76		6.2		6.2		0.64		1,300		--		8.5		290		0.3		22		0.65		750	

Source: Minnesota Pollution Control Agency, 1975.

Table 7

SURFACE WATER QUALITY DATA FROM FIVE STATIONS ALONG THE RED RIVER OCTOBER, 1977 TO SEPTEMBER, 1978

Parameter	Hickson		Fargo		Halstad		Oslo		Emerson, Manitoba	
	Minimum	Maximum	Minimum	Maximum	Minimum	Maximum	Minimum	Maximum	Minimum	Maximum
Streamflow (cfs)	62	8,940	109	2,340	408	28,700	1,100*	56,100	1,100	45,000
pH (Standard Units)	7.6	8.6	7.5	8.3	7.5	8.5	7.7*	8.5	7.7	8.4
Temperature (°C)	0.0	25.5	0.0	24.5	0.0	26.0	0.5*	8.5	0.0	25.5
Dissolved Oxygen	5.5	11.4	10.4*	12.6	5.0	9.2	10.8*	11.0	6.0	10.4
Hardness ($CaCO_3$)	210	420	240	510	250	400	300*	310	180	350
Magnesium	28	50	26	64	26	49	33*	33	17	37
Sodium (%)	9	15	10	17	14	20	14*	16	13	36
Sulfate	37	240	46	330	58	210	76*	110	63	100
Chloride	1.3	14	7.6	21	9.3	18	20*	23	12	95
Fluoride	0.1	0.3	0.0	0.3	0.1	0.7	0.2*	0.2	0.2	0.3
Total Dissolved Solids (TDS)	252	580	321	738	339	510	390*	415	251	474
Nitrogen (N)	0.01	0.75	0.30	0.49	0.0	0.81	0.1*	0.39	0.02	1.3
Phosphorus (P)	0.10	0.36	0.11*	0.26	0.15	0.39	0.16*	0.25	0.12	0.44
Boron (ug/l)	60	190	80	260	240*	--	--	--	--	--
Iron (ug/l)	20*	190	20*	--	30	120	100*	--	30*	30
Fecal Coliform (#/100ml)	--	--	2,800*	4,400	83	2,400	25*	--	113	290

*Three or less samples taken
-- No record

Note: Unless otherwise stated, all units of measure are in milligrams/liter (mg/l).

Source: U.S. Geological Survey, 1979.

Table 8

GROUNDWATER QUALITY OF MUNICIPAL SUPPLIES THROUGHOUT THE MAIN STEM

Source	Total Hardness ($CaCO_3$)	Alkalinity ($CaCO_3$)	Calcium ($CaCO_3$)	pH (Standard Units)	Iron	Manganese	Chlorides	Sulfates	Fluorides	Nitrate Nitrogen	Sodium	Total Solids
Abercrombie Well	100	350	20	7.9	0.0	0.0	90	260	2.6	10	215	1,025
Comstock Well	74	230	44	8.0	8.1	0.02	55	190	0.58	< 1	180	650
Fairmount Well	370	535	78	8.1	0.7	0.0	28	Trace	0.5	Trace	185	986
Fargo Tap	88	70	9	8.5	0.0	0.0	14	90	1.2	0.0	44	239
Halstad Well	220	250	120	7.7	0.87	0.07	480	200	0.42	< 1	420	1,300
	320	250	180	7.7	0.57	0.08	570	210	0.46	< 1	470	1,300
Karlstad Well	200	250	94	7.9	2.2	0.07	18	< 5	0.55	1.2	39	360
	130	310	56	7.7	0.54	0.02	96	< 5	1.2	1.5	150	560
Kennedy Well	340	220	180	7.8	0.16	0.19	100	95	0.19	< 1	53	610
Moorhead Well	240	190	120	7.4	5.7	0.17	2.8	45	0.17	< 1	12	440
	92	78	44	8.9	0.06	0.02	17.0	88	0.67	< 1	46	260
Rothsay Well	1,600	220	1,200	6.8	4.1	2.5	9.8	1,800	0.85	3.7	170	740
	1,700	250	1,200	7.0	4.2	2.5	5.6	1,800	0.47	< 1	170	740
Wahpeton Well	28	580	3	8.9	0.0	0.0	91	158	4.2	0.0	255	1,162

Note: Unless otherwise stated all units of measure are in milligrams per liter (mg/l).

Source: Minnesota Department of Health, 1977; North Dakota State Department of Health, 1964.

cultivated, large forest tracts were not cleared as in other portions of the basin. The growth has been restricted by nature to the floodplain of the Red River, and the wooded corridors are of significant aesthetic value in the subbasin. Extensive prairies that once provided habitat for a variety of wildlife species have been cleared, however, for agricultural purposes. In addition, poor water quality caused, in part, by municipal, industrial and rural domestic pollution has diminished the recreational and aesthetic value of the Red River.

Cultural Elements

The rich, flat valley of the Red River Main Stem has played a prominent role in the settlement geography of the entire basin throughout its prehistory and history. The junctions of the Red River with its major tributaries evidently were favored habitation sites for both prehistoric and historic man. A preliminary survey of available site information suggests that many of the prehistoric sites along the Main Stem represent temporary or seasonal occupations to accommodate the extensive periodic flooding. To date, no systematic surveys have been undertaken in the Main Stem area which would reveal the possible existence of agricultural village communities, like those which developed along the Missouri River in protohistoric times. There is no doubt, however, that bison, which roamed the Red River Plains, were always an economic focus of the native and early Euro-American populations.

The Red River Main Stem area was an important water transportation route for early explorers, trappers and traders. Subsequent development of the ox-cart trails supplanted somewhat the initial transportation function of the riverine system. Nevertheless, the Main Stem area remained the focal point of urban and agricultural development in the basin. Cities such as Fargo, Grand Forks, Moorhead, and Breckenridge grew steadily.

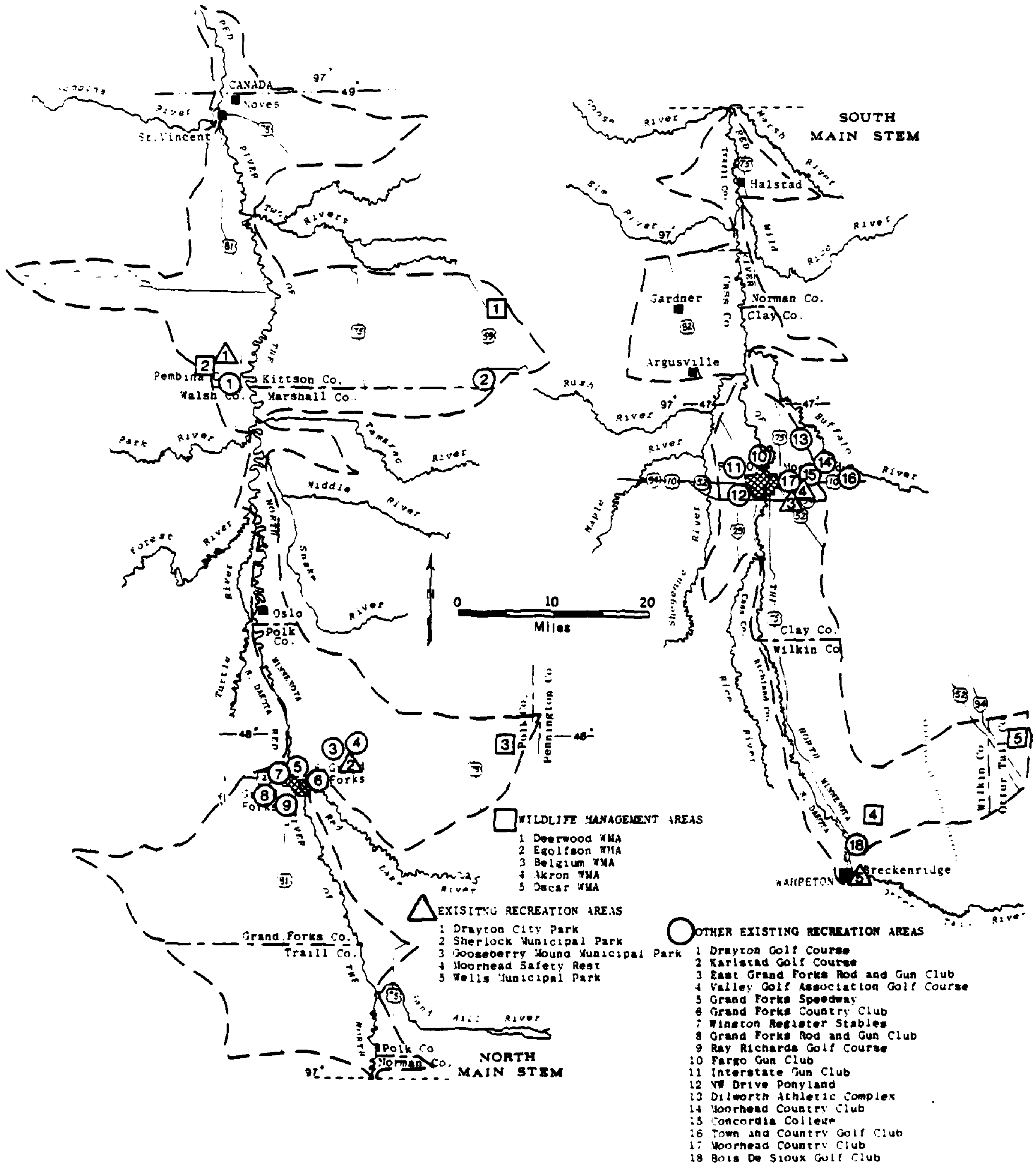
Transportation by railroads, roads, and trails were a key element in funneling homesteaders westward during the population "boom" of the 1870's. Many, indeed most, of the settlers crossed through the Main Stem area en route to North Dakota from Minnesota and Wisconsin.

The area is rich in recorded historical sites, which are located largely in cities. Over 50 sites were inventoried in Moorhead alone. Eleven sites are listed on the National Register of Historic Places and 13 are in the process of nomination. All told, an estimated 180 historical sites have been inventoried in the North Dakota and Minnesota portions of the subbasin. The importance of transportation facilities is well-represented in the historic sites inventory: 19 sites are related to railroad or road/bridge development in the Main Stem area. The majority of recorded sites represent Queen Ann-Victorian style homes, which are located in major urban centers, particularly Breckenridge and Moorhead. A systematic literature search in cooperation with field surveys will probably turn up many more sites and structures of a local, regional, state, and national significance.

Recreation Resources

Recreation resources are severely limited in the subbasin. There are approximately 4,211 acres of receational lands in the area. Recreational sites larger than 15 acres represent 54 percent of the total resources and are illustrated in Figure III. An inventory of facilities is included in Appendix B of this report. Approximately 1,870 acres or 44 percent of the total recreational lands are included in school athletic fields or municipal parks often located near the Red River and are heavily used in the subbasin. Municipal parks, however, are less than 15 acres in size. There are almost 1,100 acres included in five wildlife management areas that provide hunting opportunities in the subbasin. White-tailed deer, squirrels, muskrat, mink, rabbits, fox and raccoon are species found in the region.

There are no large lakes providing fishing opportunities in the subbasin, and poor water quality reduces the value of the Red River as a fishery resource. The river, however, is rated as a highest valuable fishery resource because of localized populations of catfish, walleye, northern pike, and crappie, particularly in the vicinity of Wahpeton. Residents of the Main Stem have historically fulfilled water-based and related recreation needs outside the subbasin. Lake Ashtabula, Orwell Dam,



Source: Gulf South Research Institute.

Figure III. RECREATIONAL RESOURCES

Devils Lake, Red Lake, Lake of the Woods, and the small lakes near Detroit Lakes are utilized by residents of the subbasin, even though it is necessary to travel great distances from population centers to reach these areas. It should be noted that the portion of the Red Lake River upstream from its confluence with the Red River at Grand Forks has been designated as a canoe river and provides recreational opportunities to residents of the subbasin. Proposed recreational sites in the subbasin are limited to the expansion of existing municipal facilities.

Significant Environmental Elements

Social

There are 30 cities and towns in the subbasin with a total urban population of 160,603 in 1977. The unincorporated population is approximately 16,758, which is only 9.4 percent of the total subbasin population. The major population centers are Fargo (57,394), Grand Forks (42,959), and Moorhead (29,219). The towns of Wahpeton, East Grand Forks, Breckenridge, Dilworth, and Drayton also represent significant population concentrations. The subbasin sustains extensive flooding damages. Grand Forks, East Grand Forks, Fargo, Moorhead, Drayton, and a number of other towns have been partially or completely inundated during periods of flooding. There has been extensive property damage in urban, residential, commercial, and industrial areas. In addition, communities are affected by the cost of evacuation and subsequent reoccupation of homes and by the disruption of normal business activity. Damages to transportation arteries cause delays in the transaction of daily commerce. The potential hazards of damages to sewage collection and treatment facilities and to municipal water supplies as a result of flooding is of particular social and environmental concern.

Even though the subbasin's population is concentrated in cities and towns, there are extensive agricultural areas in the subbasin. Agricultural lands sustain the majority of flooding damages. Approximately 600,000 acres of farmland were inundated by the 1975 flood. Damages to growing or mature crops causing reduced yields and damages to farmsteads including structures, equipment, and the loss of stored grain are pervasive and recurring problems in the subbasin. The urban centers are affected by

losses in the agricultural sector, which decreases the productivity of agricultural processing industries. The smaller towns, which are primarily agricultural service centers, may also suffer indirect economic losses related to flooding of agricultrual areas.

Cultural

The Main Stem area has played a significant role in the settlement of the entire basin throughout its history and prehistory. A complete assessment of the subbasin's known archeological resources is not possible here due to the incompleteness of the information at our disposal. However, 180 historical sites have been inventoried; 11 are listed on the National Register of Historic Places and 13 are nominated. Most of these recorded sites are in two urban communities on the Minnesota portion of the Main Stem. It seems likely that a systematic search in other towns and adjacent rural areas will identify other, potentially significan,t cultural resources.

Soils

The surface of the Red River Main Stem area is mantled by a thick layer of lacustrine sediments deposited by glacial Lake Agassiz and underlain by glacial till. The lake plain is divided into northern and southern areas by the Edinburg moraine, which extends from extreme southwest Pembina County, North Dakota, southeast to northwest Traill County, North Dakota, and then parallels the Goose River to the Red River. Areas south of the moraine have moderately fine-textured soils with a strong granular structure and topsoil eight to 14 inches thick. Subsoil is a dark grayish clay with a strong blocky structure. Soils north of the moraine are ordinarily not as fine textured as soils south of the moraine. These soils are moderately fine silty clay loams and extend north from the moraine to the Grand Forks, North Dakota, area. The Edinburg moraine does not divide the plain on the Minnesota side. Soils throughout the rest of the subbasin are fairly uniform silty clay loams and silt loams with heavy clay subsoils. Typically, these soils are moderately fine textured and imperfectly drained.

A large saline area up to 15 miles wide lies approximately four miles west of Grand Forks and extends about 14 miles to the southwest and 30 miles to the north. Most of this area is moderately saline, with

soil textures ranging from silty clay loams to loams, but areas of strong salinity are evident. A smaller but similar saline area is situated to the north in Pembina County.

Water

Less than one percent of the subbasin's land area is covered by water. The major body of water is the Red River of the North. The lack of natural or man-made lakes in the subbasin and the poor water quality of the Red River severely limit the recreational value. However, the Red River is an important source of water supply for the subbasin.

Woodlands

The woodland and brushy areas of the subbasin are considered significant because of their value as wildlife habitats, including the provision of a travel corridor along the Red River, and because of their limited areal extent. As stated previously in the Problems and Needs discussion, forests constitute only 1.1 percent (17,438 acres) of the 1,585,280-acre total Main Stem Subbasin area. Due to their importance for wildlife and their relatively limited acreage, the woodland habitats of the subbasin should be protected, conserved, and enhanced whenever possible.

Table 9 shows a comparison of the percentage of woodland vegetation in each county of the subbasin between 1969 and 1977. Each county showed an increase during the eight-year period, which can probably be attributed to the following conditions: (1) plantings of windbreaks and shelterbelts by local landowners around homesteads and streams; and (2) reestablishment of vegetation in the lower reaches of stream floodplains in lands formerly cultivated (U.S. Fish and Wildlife Service, 1980). Although this information is not available for the North Dakota portion, similar conditions are likely to exist.

Wetlands

The wetlands of the subbasin are important because of their many beneficial uses and values such as groundwater recharge, sediment and nutrient traps, storage of water during spring runoff and periods of extreme precipitation, habitats for plants and animals, and waterfowl

Table 9

COMPARISON OF COUNTY PERCENTAGES OF WOODLAND VEGETATION BETWEEN 1969 AND 1977

County	Percentage of County Containing Woodland Vegetation 1969	1977	Change in Percent Composition
Kittson	9.6	15.5	+5.9
Marshall	11.5	17.1	+5.6
Polk	5.1	6.7	+1.6
Norman	4.6	5.1	+0.5
Clay	2.8	3.0	+0.2
Wilkin	0.6	0.7	+0.1

Source: Minnesota Land Management Information Service in U.S. Fish and Wildlife Service (1980).

production areas (Cernohous, 1979; U.S. Fish and Wildlife Service, 1979, 1980; E.O. 11990, dated 24 May 1977). As with the woodlands, wetlands are significant because their number and areal extent have been decreased substantially through conversion to agricultural lands, urban areas, and other land uses. There is also a need to preserve, conserve, and enhance these valuable and fragile ecosystems, whenever possible.

Table 10 gives number and acreage values of wetlands in the Minnesota and North Dokatoa counties included by the subbasin. The figures were obtained during a 1964 inventory based on a 25 percent sampling of the wetlands within these counties. The number and acreage of all Type 3, 4, 5, 10, and 11 wetlands were multiplied by four to expand the 25 percent sample to 100 percent. Type 1 wetlands were not measured in the 1964 survey. The number and acreage of Type 1 wetlands, however, were estimated

Table 10

1964 WETLAND INVENTORY DATA FOR THE TEN COUNTIES INCLUDED BY THE MAIN STEM SUBBASIN

	Wetland Types[a]											
	1		3		4		5		10		Total	
County	Number[b]	Acres[c]	Number	Acres	Number	Acres	Number	Acres	Number	Acres	Number	Acres
Minnesota												
Polk	1,721	2,718	2,097	5,340	537	5,251	234	7,526	--	--	4,589	20,835
Clay	1,574	1,411	1,881	3,687	567	3,548	176	2,169	--	--	4,198	10,815
Wilkin	166	506	241	1,187	32	2,058	4	125	--	--	443	3,876
Ottertail	7,025	6,656	9,218	18,710	1,434	12,193	1,057	13,469	--	--	18,734	51,028
North Dakota												
Pembina	14	23	19	75	4	77	0	0	--	--	37	175
Walsh	2,120	1,759	3,500	10,982	30	700	4	45	--	--	5,654	13,486
Grand Forks	772	927	1,270	3,936	8	680	0	0	8	1,562	2,058	7,105
Traill	25	127	38	471	4	376	0	0	--	--	67	974
Cass	411	414	646	1,938	39	823	0	0	--	--	1,096	3,175
Richland	1,087	2,949	1,464	4,465	316	10,592	32	4,600	--	--	2,899	22,606
TOTAL	14,915	17,490	20,374	50,791	2,971	36,298	1,507	27,934	8	1,562	39,775	134,075

[a]Type 1 - Seasonally flooded basins and flats.
Type 3 - Shallow fresh marshes.
Type 4 - Deep fresh marshes.
Type 5 - Open fresh water.
Type 10 - Inland Saline Marshes.

[b]Calculated at 60 percent of total wetland numbers.

[c]Calculated at 15 percent of total wetland acres.

Source: U.S. Fish and Wildlife Service (1979, 1980).

based on previous studies, which indicated that they comprise about 60 percent of the total wetland numbers and 10-15 percent of the total wetland acres in the Prairie Pothole Region. As of 1964, a total of 39,775 wetlands representing 134,075 acres remained within 10 of the 13 counties in the Main Stem Subbasin. An inventory was not conducted in Kittson, Marshall, and Norman counties in this year. In addition, a major portion of the wetlands and their acreages will not occur within the heavily agriculturalized lands of the subbasin, but in that portion of the county outside of the subbasin boundaries. This is particularly true in those counties whose farthest limits away from the Red River have more rugged topography where many of the existing wetlands occur. These areas of greater relief are not within the flat lands of the glacial Lake Agassiz lowlands.

Table 11 shows wetland numbers and acreages for 1974 in Polk, Clay, Wilkin, Ottertail, and Norman counties in Minnesota; no 1974 inventory data are available for North Dakota. The 1974 sampling represented a 100 percent inventory. In addition to the wetland types surveyed in the 1964 investigation, exclusive of Type 1 wetlands, Types 6 and 7 and stockponds are included. Table 12 shows a comparison of the 1964 and 1974 wetland inventory data for types 3 to 5. These data are comparable since methods used in the 1974 survey allowed direct comparison of the same sampling locations at the 25 percent level sampling. These data show that the numbers and acreage of Type III, IV and V wetlands in Polk, Clay, Wilkin and Ottertail Counties have been reduced by 5,532 and 4,564 acres, respectively, during the period from 1964 to 1974. Although no acreage figures are available for the North Dakota portion of the subbasin, most of the wetlands in eastern North Dakota have also been drained and converted to cropland. Current annual wetland drainage estimates are thought to be less than two percent of the remaining wetland base, except in isolated areas where they may be higher (U.S. Fish and Wildlife Service, 1979).

<u>Waterfowl Production Areas</u>

Waterfowl Production Areas (WPAs) are wetland areas that the U.S. Fish and Wildlife Service (FWS) has either acquired through fee title, or obtained an easement interest in, to preserve valuable breeding, nesting

Table 11

1974 WETLAND INVENTORY DATA FOR FIVE MINNESOTA COUNTIES IN THE MAIN STEM SUBBASIN

	Wetland Type															
	3		4		5		6		7		8		Stock Ponds		Total	
County	Number	Acres	Number	Acres	Number	Acres	Number	Acres	Number	Acres	Number	Acres	Number	Acres	Number	Acres
Polk	1,432	8,413	438	4,138	351	15,745	416	4,277	4	40	--	--	146	--	2,787	32,613
Clay	1,299	7,338	311	3,671	158	5,652	393	7,249	61	673	--	--	165	--	2,387	24,583
Wilkin	108	3,614	15	218	3	177	9	28	--	--	--	--	32	5	167	4,042
Ottertail	4,127	16,217	2,110	20,275	1,251	31,128	1,877	11,986	23	408	9	153	288	33	9,685	80,200
Norman	389	2,158	177	1,636	4	34	50	1,610	1	100	--	--	21	2	642	5,540
TOTAL	7,355	37,740	3,051	29,938	1,767	52,736	2,745	25,150	89	1,221	9	153	652	40	15,668	146,978

Source: U.S. Fish and Wildlife Service (1980).

Table 12

COMPARISON OF 1964 WETLAND INVENTORY SHOWING NUMBER, ACREAGE,[a] AND PERCENT CHANGES FOR COUNTIES WITHIN THE MAIN STEM SUBBASIN

County	Wetland Types 3 Number	Percent	Acre	Percent	4 Number	Percent	Acre	Percent	5 Number	Percent	Acre	Percent	Total Number	Percent	Acre	Percent
Polk	-259	-12.4	+113	+2.1	-18	-3.4	-1,392	-26.5	-20	-8.5	-179	-2.4	-297	-10.4	-1,458	-8.0
Clay	-418	-22.2	+472	+12.8	-300	-52.9	-1,154	-32.5	-60	-34.1	-400	-18.4	-778	-29.6	-1,082	-11.5
Wilkin	-147	-61.0	-337	-28.3	-5	-15.6	+516	+25.0	--	--	-61	-48.8	-152	-54.9	+118	+3.4
Ottertail	-5,094	-55.3	-3,676	-19.6	+801	+55.9	+1,264	+10.3	-12	-1.1	+270	+2.0	-4,305	-36.8	-2,142	-4.8
TOTAL	-5,918	--	-3,428	--	+478	--	-766	--	-92	--	-370	--	-5,532	--	-4,564	--

[a] Represents values expanded to 100 percent from a 25 percent sample.

Source: U.S. Fish and Wildlife Service (1980).

and feeding habitat for migratory waterfowl. These wetland areas are purchased, or an easement interest obtained, with funds received from the sale of migratory bird hunting and conservation stamps (Duck Stamps). These WPA's are significant because they provide the public with a great variety of wildlife-oriented recreational opportunities, as well as provide valuable habitat for migratory waterfowl and many other forms of wildlife. FWS is responsible for the compatibility determinations (uses) and the issuance and denial of permits involving these lands. WPA's acquired in fee title are managed for optimum wildlife production, particularly waterfowl. On easement WPA's, the rights acquired are limited to the burning, draining and filling of wetland basins and right of access. All other property rights remain with the landowners. The approximate locations of WPA's acquired in fee within the subbasin are shown in Figure IV.

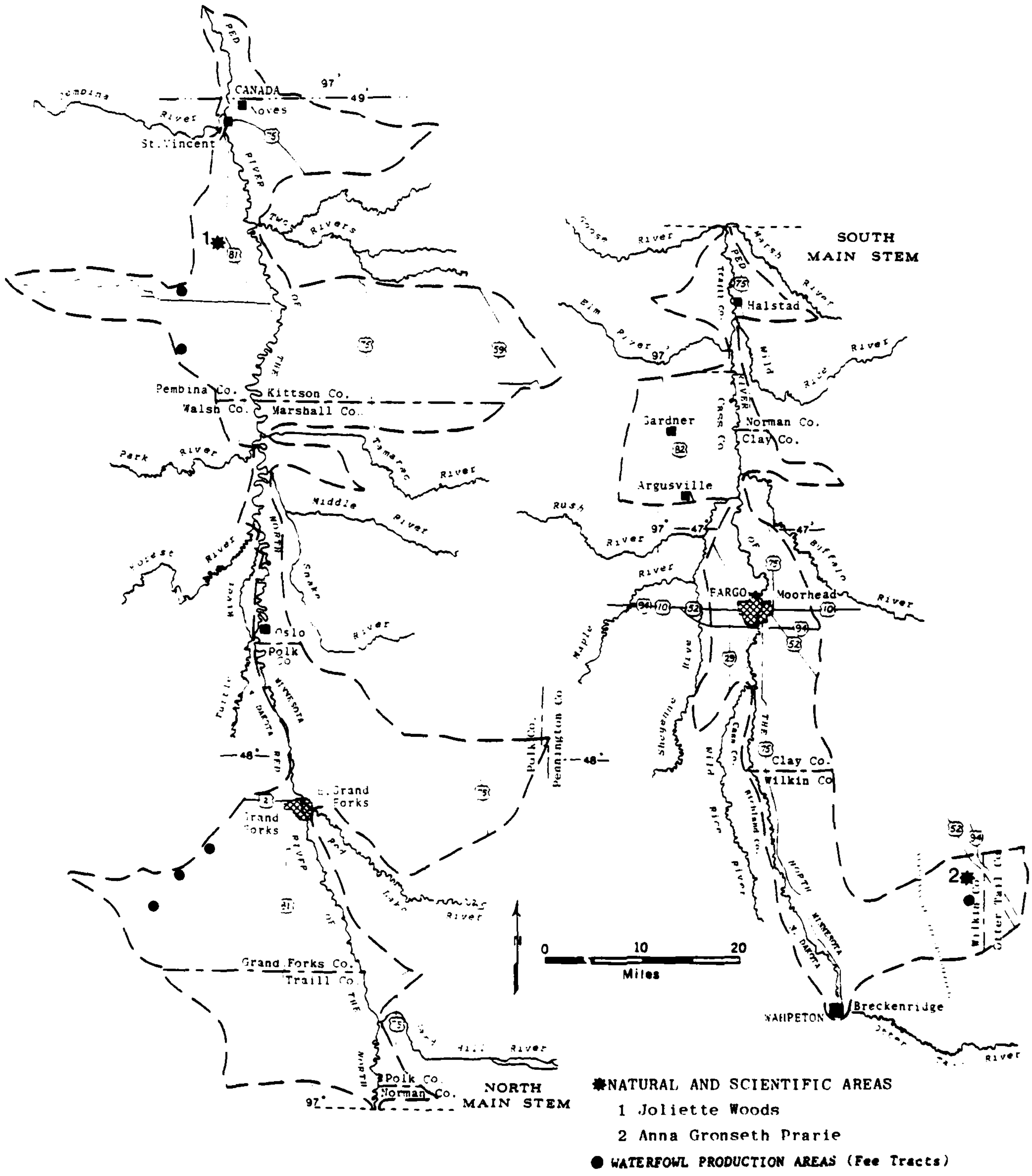
Wildlife Management Areas

Five wildlife management areas or refuges are found within the subbasin. A list of these areas and their acreages and locations were presented in the Existing Conditions section for recreation. These areas are significant because of the opportunities provided for outdoor recreation and protection and management given to biological resources in a region that is intensively farmed and disturbed to a large extent by urban development and other land uses.

Threatened or Endangered Species

Many animals that are considered to be endangered or threatened have been reported from the counties included in the subbasin. These species and others of special interest are listed in Table 13. The status classifications used in this table are defined by McKenna and Seabloom (1979) and Henderson (1979) as follows:

- Endangered - species whose existence throughout their ranges in the state are in immediate danger of extirpation.
- Threatened - species that are in such small numbers in the state as to make them likely to become endangered in the foreseeable future.



Source: North Dakota State Comprehensive Outdoor Recreation, 1975; Kantrud, 1973; Nature Conservancy, no date; Miles and Yaeger, 1979; U.S. Fish and Wildlife Service, 1980.

Figure IV. WATERFOWL PRODUCTION AREAS SCIENTIFIC AND NATURAL AREAS

Table 13

ANIMAL SPECIES OF SPECIAL IMPORTANCE FOUND WITHIN THE MAIN STEM SUBBASIN

Class	Common Name	Status[1]	Habitat	Primary Reason(s) For Decline	Reference[2]
Mammalia	Timber wolf	E	Primitive wooded areas	Loss of habitat; hunting and trapping pressures	2, 4, 5, 7
	Black bear	E	Extensive forests	Unknown; possibly hunting and trapping pressures	2
	River otter	E	Stream and lake borders	Trapping pressure	2
	Mountain lion (cougar)	E	Rugged terrain, extensive forests, and swamps	Pressures brought on by civilization	2, 4, 7
	American elk	E	Prairies and hardwood-prairie borders	Loss of habitat; illegal hunting	4, 7
	Eastern mole	Pe	Burrows in sandy loam soils	--	2
	Plains pocket mouse	Pe	Prairies with sandy soil	--	2, 4
	Northern grasshopper mouse	Pi	Prairie and grasslands	--	4, 5
	Prairie vole	Pi	Prairie and grasslands	--	5
	Northern pocket gopher	Pi	Prairie and grasslands	--	5
	Spotted skunk	Pi	Prairie and grasslands	--	4
	Least weasel	Pi	Prairie and grasslands	--	4
	Long-tailed weasel	Pi	Cosmopolitan	--	4
Aves	Northern bald eagle	E	Shorelines (with large trees) of lakes and rivers	Loss of habitat; pesticide pollution	2, 4, 5, 7
	Osprey	E	Timbered shorelines of lakes and rivers	Loss of habitat; pesticide pollution	2, 7
	American and Artic peregrinefalcons	E	Nests in cliffs and steep riverbanks; feeds over prairies and open waterways	Pesticide pollution--especially DDT and its derivatives	2, 7
	Greater prairie chicken	E	Native tall-grass prairies or similar grasslands	Loss of habitat due to agricultural operations	5, 7
	Greater sandhill crane	E	Prairie marshes and similar wetlands	Drainage of wetlands	5, 7
	Pileated woodpecker	Pe	Extensive stands of mature deciduous or mixed forests	--	2, 7
	Northern water thrush	Pe	Understores of forested areas near bogs, lakes and rivers	--	2
	Mourning warbler	Pe	Dense underbrush	--	2
	Baird's sparrow	Pi	Prairies and similar grasslands	--	5
	Sprague's sparrow	Pi	--	--	5
	Chestnut-collared longspur	Pi	Plains and prairies	--	5
	Marbled godwit	Pi	Marshy prairies; shallow pools	--	5
	Western grebe	Pi	Shallow lakes located within prairies	--	5, 7

-continued-

Table 13 (Cont'd)

ANIMAL SPECIES OF SPECIAL IMPORTANCE FOUND WITHIN THE MAIN STEM SUBBASIN

Class	Common Name	Status[1]	Habitat	Primary Reason(s) For Decline	Reference[2]
Pices	Lake sturgeon	E	Large lakes and rivers	Overharvest and loss of habitat	1, 2, 7
	Northern red belly dace	T	Slow flowing creeks or impoundments with abundant vegetation and clear water	Loss of habitat	2
	Central mudminnow	Pe	Ditches, ponds, streams	--	2
	River shiner	Pe	Large rivers with sandy bottoms	--	2
	Blackchin shiner	Pe	Clear, quite pools with abundant vegetation	--	2
	Greater red horse	Pe	Large, clear streams with sand or gravel bottoms	--	2
	River darter	Pe	Large, deep, and swift rivers with sand or gravel bottoms	--	2
	Trout-perch	Pe			
	Least darter	Pi	Small, clear streams with vegetation	--	1, 7
	Pugnose shiner	Pi	Clear streams with abundant vegetation	--	1, 2, 7
Amphibia	Gray tree frog	Pe	Shrubs or trees near shallow bodies of water	--	2
	Mud puppy	Pe	Almost any permanent body of water	--	2
	Canadian toad	Pe	Along shorelines of small lakes	--	3
	Great plains toad	Pe	Open grassy areas or along small streams and ditches	--	3
Reptilia	Prairie skink	Pe	Open grassy areas with sandy soil	--	2
	Smooth green snake	Pe	Upland prairies and grasslands	--	3
Insecta	Dakota skipper	E	Virgin prairies	Loss of habitat	5, 6
	Garita skipper	Pi	Grasses and shrubs in open areas	--	5
	Uhler's artic	Pi	--	--	5
	Assiniboia skipper	Pi	--	--	5

[1] Status: E = Endangered; T = Threatened; Pe = Peripheral; Pi = Priority species

[2] References:
1 = U.S. Fish and Wildlife Service, 1979. Aquatic Resources Package.
2 = McKenna, Michael G. and Robert W. Seabloom, 1979. Endangered, Threatened, and Peripheral Wildlife of North Dakota.
3 = Henderson, Carrol, 1979. The Occurrence, Distribution, Legal Status, and Utilization of Reptiles, and Amphibians in Minnesota.
4 = Henderson, Carrol, 1979. The Taxonomy, Distribution, Legal Status, and Utilization of Non-Game Mammals in Minnesota.
5 = Minnesota Natural Heritage Program, 1980. *Rare Elements of Natural Diversity Found in 21 Counties of the Minnesota Red River Basin.*
6 = McCabe, Tim L. and Richard Lewis Post, 1977. Skippers (Hesperioidea) of North Dakota.
7 = Moyle, John B., 1974. Minnesota Animals and Plants in Need of Special Consideration with Suggestions for Management.

- Peripheral - species that are found at only a few sites in the state because the state is at the edge of their range.
- Priority - species that are rare or uncommon throughout their range, or that require a unique habitat. These species require further study to determine their exact status or distribution.

Rare and Unique Plants

Table 14 lists the rare and unique plants found within the subbasin. This table was compiled from two sources: Barker, et al. (1976); and Minnesota Natural Heritage Program (1980). Barker's classification scheme is based upon plant distribution records from the North Dakota State University Herbarium. If a species was reported from three or less counties and there were only a few individuals at these recording stations, the species is considered rare. If there were many individuals at these recording stations and they were widespread in occurrence, the species was considered to be unique. The species listed by the Minnesota Natural Heritage Program are considered to be of a significant importance because of their rarity or exemplary nature.

Natural Areas

Two natural areas are located within the subbasin: (1) Anna Gronseth Prairie, and (2) Joliette Woods. The Anna Gronseth Prairie is a 760 acre block located approximately three miles west and three miles south of Rothsay (Wilkin County, Minnesota). The prairie is situated along the beach ridge of Glacial Lake Agassiz and supports populations of prairie chickens, upland plovers, marbled godwits, and marsh hawks (The Nature Conservancy, no date). The other natural area, Joliette Woods, is located near Joliette (Pembina County, North Dakota). This area is the largest remaining tract of bottomland forest along the Red River of the North (Kantrud, 1973). The approximate location of both areas is shown on Figure IV.

Table 14

RARE AND UNIQUE PLANTS OF THE MAIN STEM SUBBASIN

Name	Counties	Habitat	Source*
Astralugus flexosus	Clay	Upland, dry plains	1, 3, 5
Calamagrostris montanensis	Clay, Norman, Polk	Dry plains	1, 3
Chamaerhodos nuttallii	Clay, Polk	Plains	1, 3
Gentiana macounii	Clay	Prairies, edges of marshes with gravelly soil	1, 3
Helianthus nuttallii	Clay	Mountain valleys	1, 3
Orobanche fasiculata	Clay, Kittson	Parasitic on roots or composite flowers (in sandy soil)	1, 3
Orobanche ludoviciana	Clay, Kittson, Polk	Parasitic on roots or composite flowers (in sandy soil)	1, 3
Platanthera leucophea	Clay, Norman, Polk	Prairies	1, 4
Poa sylvestris	Clay	Woods and thickets	1, 3
Puccineillia nuttalliana	Clay, Kittson, Wilkins	Saline soil	1, 3
Caulophyllum thalictroides	Cass	Rich and moist soils	2
Aster sericeus	Cass	Upland prairie	2
Antennaria aprica	Kittson, Polk	Dry plains, hills	1, 3
Arabis holboellii var. retrofacta	Kittson	Upland plains, dry hills	1, 3
Arenaria stricta ssp dawsonensis	Kittson	Rocky outcrops	1, 3
Carex conoidea	Kittson	Damp slopes	1, 4
Limosella aquatica	Kittson	Shallow water areas with muddy bottoms	1, 3
Rannuculus gmelini	Kittson	Peat or sphagnum bogs	1, 4
Sahlicornia cubra	Kittson	Border of alkaline lakes	1, 3
Stellaria longipes	Kittson, Marshall	Low, wet areas	1, 3
Tofieldia glutinosa	Kittson, Polk	Low, wet areas	1, 3
Carex cappillaris var. major	Marshall	Moist grounds around lakes	
Astrilagus lotiflorus	Norman	Upland plains	
Eleocharis pauciflora var. fernaldi	Norman	Low, wet meadows	
Gentiana affinis	Polk, Wilkins	Dry hills	
Potentilla effusa	Polk	Plains and hills	
Senecio canus	Polk	Dry hills	
Bacopa rotundifolia	Wilkin	Emergent aquatic	1

*1 = Minnesota Natural Heritage Program. 1980. Rare Elements or Natural Diversity Found in 21 Counties of the Minnesota Red River Basin.
2 = Barker, William T., Gary Larson, and Richard Williams. No date. Rare and Unique Plants of North Dakota.
3 = Rydberg, Per Axel. 1932. Flora of the Prairies and Plains of Central North America.
4 = Lakela, Olga. 1965. A Flora of Northeastern Minnesota.
5 = MacMillan, Conway, ed. 1898. Minnesota Botanical Studies, Vol. I.

V. FUTURE CONDITIONS

V. FUTURE CONDITIONS

The following discussion of the subbasin focuses on a presentation of "most probable" and "without project" future economic and population conditions and likely environmental aspects.

Most Probable Economic Conditions

As required by the Principles and Standards, consideration was given to the adaption of OBERS Series E and E' projections of general economic and demographic parameters for BEA economic areas 92 and 97 (Grand Forks and Fargo-Moorhead). However, these series were not adopted because recent trends have shown a stabilization and, in the case of several urban communities, a reversal of past steady decreases in population and employment within the subbasin. State, regional and GSRI developed projections are therefore recommended as the most probable statistics. OBERS Series E and E' per capita income and future agricultural activity projections have nevertheless tracked adequately and were thus deemed adequate for the purposes of this reconnaissance investigation.

Table 15 presents population, employment and per capita income (expressed in 1979 dollars) figures for the subbasin.

These figures primarily reflect population and employment growth in the cities of Fargo, Moorhead, Grand Forks-East Grand Forks, and Wahpeton. These cities will account for over 80 percent of the subbasin's population. Other smaller towns and villages are also expected to make population gains, mostly stemming from suburbanization patterns and additional job opportunities associated with the larger urban areas.

Regional planners anticipate that the cities of Fargo and Grand Forks and their environs will serve as metropolitan service centers for an area that influences a 15-mile to 30-mile radius. Wahpeton and Breckenridge should continue to serve as regional service centers for an area of up to 20 miles in radius.

Agriculture, which accounted for well over 90 percent of the area's basic employment prior to the 1960's, is expected to remain above 50 percent throughout the projection period. Agricultural employment will continue to be of greater importance in the Fargo area, as the Grand Forks region will have a more diversified employment base. Military employment is forecast to stabilize following some decreases in the 1970's.

Table 15

MAIN STEM SUBBASIN POPULATION, EMPLOYMENT AND PER CAPITA INCOME PROJECTIONS (1980-2030)

Parameter	Year							
	1970	1977	1980	1990	2000	2010	2020	2030
Population	166,072	177,361	180,000	189,000	198,000	208,000	219,000	230,000
Employment	61,447	83,360	84,000	87,000	91,000	96,000	100,000	106,000
Per Capita Income (1979 Dollars)	6,121	7,709	10,000	13,000	16,900	22,000	28,600	37,100

Sources: U.S. Water Resources Council, 1972 Projections, Series E; Northwest Regional Development Council; West Central Regional Development Commission; Lake Agassiz Regional Council; Red River Regional Council; and Gulf South Research Institute.

Most Probable Agricultural Conditions

Approximately 1.2 million acres within the subbasin are currently under cultivation, and wheat, barley and sunflowers are the principal crops. The estimated value of the total production of these principal crops for 1980, using October 1979 Current Normalized Prices (prerevised) averaged for North Dakota and Minnesota, is $98.1 million. Projections of total production through 2030 for the principal crops is presented in Table 16. The projected total production for 2030 represents a value of $164.7 million, using October 1979 Current Normalized Prices (prerevised) averaged for North Dakota and Minnesota.

Table 16

MAIN STEM SUBBASIN, PRINCIPAL CROPS AND PROJECTED PRODUCTION 1980-2030
(Production in Thousands)

Year	Wheat (Bushels)	Barley (Bushels)	Sunflowers (Pounds)
1980	17,346	12,833	239,976
1990	20,121	14,886	278,372
2000	22,897	16,940	316,768
2010	24,631	18,223	340,766
2020	26,366	19,506	364,764
2030	29,141	21,559	403,160

Sources: OBERS Series E'; and Gulf South Research Institute.

Evaluation of Flood Damages--Future Conditions

A summary of present and future average annual flood damages is presented in Table 17. Assuming a discount rate of 7 1/8 percent, average annual equivalent damages throughout the projection period are expected to be $11,133,500. Urban damages account for 33 percent of the equivalent average annual damages, and rural damages account for the remaining 67 percent.

Table 17

MAIN STEM SUBBASIN, SUMMARY OF PRESENT AND FUTURE AVERAGE ANNUAL DAMAGES URBAN, AGRICULTURAL, AND TRANSPORTATION (October, 1979 Prices, 7 1/8 Percent Interest)

Category	Flood Damages 1980	1990	2000	2010	2020	2030	Increase 1980-2030	Average Annual Equivalent Factor	Average Annual Equivalent of Increase	Equivalent Average Annual Damages
Urban										
Argusville	23,900	26,300	28,700	31,100	33,500	35,900	12,000	0.2903	3,500	27,400
Bowesmont	16,300	17,900	19,600	21,200	22,800	24,500	8,200	0.2903	2,400	18,700
Breckenridge	114,400	125,800	137,300	148,700	160,200	171,600	57,200	0.2903	16,600	131,000
Brooktree Park	28,200	31,100	33,900	36,700	39,500	42,400	14,200	0.2903	4,100	32,300
Drayton	30,600	33,700	36,700	39,800	42,800	45,900	15,300	0.2903	4,400	35,000
East Grand Forks	715,500	787,100	858,600	930,200	1,001,700	1,073,300	357,800	0.2903	103,900	819,400
Fargo	358,800	394,700	430,600	466,400	502,300	538,200	179,400	0.2903	52,100	410,900
Grand Forks	1,308,300	1,439,100	1,570,000	1,700,800	1,831,000	1,962,500	654,200	0.2903	189,900	1,498,200
Halstad	44,000	48,400	52,800	57,200	61,600	66,000	22,000	0.2903	6,400	50,400
Harwood	99,800	109,700	119,800	129,800	139,700	149,700	49,900	0.2903	14,500	114,300
Moorhead	246,000	270,600	295,200	319,800	344,400	369,000	123,000	0.2903	35,700	281,700
Noyes	7,800	8,900	9,400	10,100	10,900	11,700	3,900	0.2903	1,100	8,900
Oslo	7,800	8,900	9,400	10,100	10,900	11,700	3,900	0.2903	1,100	8,900
Perley	37,000	40,700	44,400	48,100	51,800	55,500	18,500	0.2903	5,400	42,400
Rivertree	60,300	66,300	72,300	78,400	84,400	90,400	30,100	0.2903	8,700	69,000
Robin	10,000	11,000	12,000	13,000	14,000	15,000	5,000	0.2903	1,500	11,500
St. Vincent	33,500	36,900	40,200	43,600	46,900	50,300	16,800	0.2903	4,900	38,400
Wahpeton	101,900	112,100	122,300	132,500	142,700	152,900	51,100	0.2903	14,800	117,000
Agricultural										
Crop	4,636,700	5,378,600	6,120,400	6,584,100	7,047,800	7,789,700	3,153,000	0.2903	915,300	5,552,000
Other Agricultural	1,545,600	1,669,200	1,792,900	1,870,200	1,947,500	2,071,100	525,500	0.2903	152,600	1,698,200
Transportation	167,900	167,900	167,900	167,900	167,900	167,900	--	--	--	167,900
TOTAL	9,594,300	10,784,900	11,974,400	12,839,700	13,704,900	14,895,200	5,300,900	0.2903	1,538,900	11,133,500

Source: Gulf South Research Institute.

Flood damages to residences, businesses, industrial structures, churches, schools, automobiles, house trailers, public property and contents are included in the urban damages category. Damages to streets and utilities (including water, gas, electricity, sanitary sewers, storm sewers, and telephone systems) are also taken into consideration. This category also includes loss of wages, loss of profits, expenditures for temporary housing, cleanup costs, and extra expenses for additional fire and police protection and flood relief.

Agricultural flood damages consist of crop and pasture damage, which may include costs of replanting, refertilizing, additional spraying, reduced crop yields, loss of animal pasture days, and other related flood losses.

Other agricultural damages consist of land damage from scour and gully erosion and deposition of flood debris; livestock and poultry losses; damages to machinery and equipment, fences, and farm buildings and contents (excluding residences); and damages to irrigation and drainage facilities.

Transportation damages include all damages to railroads, highways, roads, airports, bridges, culverts, and waterways not included in urban damages. In addition, all added operational costs for railroads and airlines and vehicle detours are included.

Future growth of urban flood damages was estimated to be an uncompounded (straight-line) rate of one percent per year for a 50-year period beginning in the base year, with no growth thereafter.

Agricultural crop flood damages were projected to increase at the same rate as crop income projections published in the 1972 OBERS Series E projection report. These crop income projections were prepared by the U.S. Economic Research Service (ERS) for the Red River of the North region. Other agricultural flood damages were projected to increase at one-half of this rate.

Transportation damages are not expected to change throughout the project life because of the long-term economic life associated with such structures as bridges, railways, roads, and culverts. In addition, it has been found that repairs to these types of structures rarely exceed the cost of a new structure, even with frequent flooding.

Most Probable Environmental Conditions

Implementation of point source programs will result in improvements in industrial and municipal effluents and concurrent improvements in the water quality of the Red River. This includes improvements in both the Main Stem area and in the tributary streams. Nonpoint source pollution abatement programs will also improve water quality for aquatic life and wildlife resources. However, this program is expected to take considerably longer than those related to point sources. As a result of this delayed time period, problems will continue with nutrient and pesticide pollution, as well as with excessive turbidities associated with runoff from the substantial farmlands of the Main Stem and tributary stream subbasins. Low dissolved oxygen levels, and their deleterious effects on aquatic biota, will continue to exist during times of low flows and extreme winter conditions.

Barring any changes in current land use trends, native woodland habitats are expected to decrease through encroachment by agricultural and urban land uses. These have been offset in many cases by increased plantings of shelterbelts and windbreaks, but these may or may not be of similar quality to the native woodlands and brushy areas that are eliminated. Few wetlands, remain in the Main Stem Subbasin as compared to their original number and extent, and they will continue to decline through drainage for cropland uses. Additionally, those that remain are subject to degradation or elimination by channelization, sedimentation, and further land use changes. The gradual loss of these native and valuable habitats will result in decreases in plant and animal populations dependent wholly or in part upon these environs, as well as their other important functions.

Without Project Conditions

It is anticipated that the conditions that will prevail over the 50-year planning period in the absence of a plan to alter resource management procedures will be the same as those set forth previously under the most probable future scenario.

VI. EXISTING FLOODPLAIN MANAGEMENT PROGRAMS

VI. EXISTING FLOODPLAIN MANAGEMENT PROGRAMS

Institutions

Institutional arrangements in the Main Stem are the most complicated in the Red River of the North Basin. Portions of the states of Minnesota and North Dakota are included in the Basin and are subject to numerous state laws affecting water resources. The northern border of the subbasin is at the Canadian border. Differences in state law contribute to disputes among water users and impede the resolution of flooding problems. The state of Minnesota recognizes the common law riparian doctrine modified by state statute. In this state, the owner of land is entitled to any surface or groundwater that comes into contact with his property. State approval, however, is necessary to perfect water rights, and reasonable use is granted to upstream and downstream landowners. In North Dakota, the prior appropriation doctrine forms the basis for water rights. According to appropriation, the state is owner of all water within its boundaries. An individual must acquire state approval to acquire water rights by showing the intention of using the water for beneficial purposes for a specified period of time. If disputes arise, the holder of the permit issued earliest has the greater right. The fundamental differences in legal approaches to water rights separate the Dakotas from Minnesota and complicate water resources planning in the subbasin.

The development of effective water resources management practices in the subbasin is affected by the large number of international, Federal, state, and local agencies involved in project planning and implementation. A portion of the subbasin lies within Canada. For the U.S. portion of the subbasin, there are 44 Federal agencies with various types of jurisdiction and 14 directly involved in the water and related land resource planning process. At the state level, 35 agencies are involved. There are also regional commissions, county agencies, and municipal entities. Differences in perspective and problems of coordination hamper the effective and speedy resolution of problems.

The major Federal agencies with authority in the subbasin a U.S. Army Corps of Engineers and the Soil Conservation Service. Corps has completed six flood control projects in the subbasin, SCS has completed the Midland-Drayton and Joe River projects in subbasin.

On the local level, there are seven Minnesota Watershed Dis with jurisdiction in the subbasin, including the Joe River, Two Middle-Snake, Red Lake, Sand Hill, Wild Rice, and Buffalo distric Eight North Dakota Water Management Districts (Pembina, Walsh, G Forks, Traill, North Cass, Rush, Southeast Cass, and Richland) a authority in the Main Stem. These districts possess broad powers to the general management, conservation, and utilization of water Areas of responsibility include flood control, water supply, wate improvements, drainage, irrigation, pollution control, and recrea in the respective jurisdictions. The Minnesota districts have de watershed plans, but only the Traill and Southeast Cass Water Man Districts in North Dakota have formulated overall plans. The Nor districts are hampered in the effective resolution of flooding pr by the organizational structure of the districts based on a count rather than on hydrological units. There is no watershed managem plan that applies to the entire Main Stem as a separate and disti hydrological area, and with the exception of the lower Red River Management Board, there is no formal institutional arrangement th coordination between the multitude of districts exercising jurisd in the subbasin. In addition to the 15 watershed and water manag districts, there are 12 soil and soil and water conservation dist with authority in the area. Minnesota Soil and Water Conservatio include those representing Kittson, Marshall, Polk, Norman, Clay, Wilkin counties. The North Dakota Soil Conservation Districts in Pembina, Walsh, Grand Forks, Traill, Cass and Richland counties.

It should also be noted there are four regional planning cou including the Red River and Lake Agassiz Regional Planning Counci North Dakota and the Northwest and West-Central Regional Developm Commissions in Minnesota that have developed overall economic dev plans for areas encompassing the Main Stem Subbasin.

Structural Measures

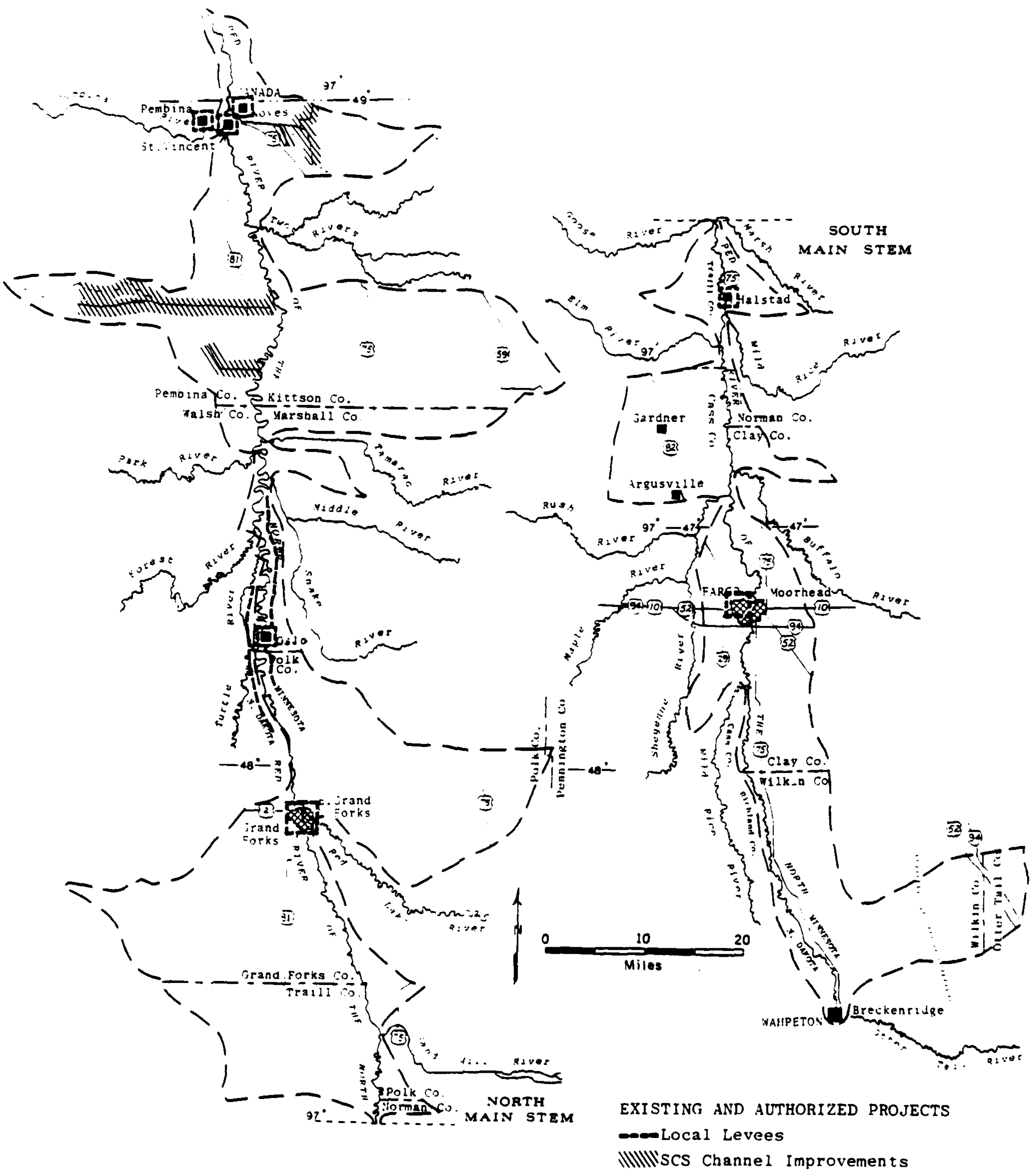
The Corps of Engineers, Soil Conservation Service (SCS), state, local and private interests have constructed numerous flood prevention projects along the Main Stem of the Red River of the North both in urban and rural areas. In addition to projects constructed along the Main Stem, some existing SCS and Corps of Engineers projects along tributary streams have also reduced flooding along the Main Stem. The Corps of Engineers presently has an authorized project at East Grand Forks, Minnesota and is evaluating under Section 205 authority, the feasibility of flood control projects at Argusville, North Dakota and Halstad, Minnesota.

The locations of floodwater control and agricultural water management (drainage) measures constructed by the various agencies and local interests are shown in Figure V and include the following:

1. In 1963, the Corps completed a project at Fargo, North Dakota consisting of 3,500 linear feet of levee between First and Ninth Avenues South, a river cutoff near St. John's Hospital, and three downstream cutoffs to reduce flood stages throughout the city. During the 1969 flood, the levee was extended approximately 1,300 feet upstream to protect an additional 50 low-lying residences. A levee project for Moorhead was authorized by Congress, but was not constructed due to lack of local interest.

2. The 1948 and 1950 Flood Control Acts authorized local flood protection works at Grand Forks and East Grand Forks. In 1956, the Corps constructed a flood protection project in the Lincoln Park area of Grand Forks which consisted of 5,160 linear feet of earthen levee and 770 feet of concrete floodwall plus associated interior drainage works. Emergency levee works constructed during the 1975 flood remain at two locations in Grand Forks. A 1,500-foot-long earthen levee protects the Central Park area, and a 2,800-foot-long earth levee plus a 650-foot-long wood plank floodwall protect the Riverside Park area. Detailed plans for the East Grand Forks unit were prepared, but construction was not begun because the city was unable to provide the assurances of local cooperation at that time. Approximately 8,000 linear feet of emergency levee exists in East Grand Forks.

3. Oslo has a completed local protection project consisting of 14,700 linear feet of earthen levee with associated interior drainage works.



Source: Gulf South Research Institute.

Figure V. EXISTING FLOOD CONTROL MEASURES

4. As part of the 1969, 1978, and 1979 flood emergency efforts, the Corps has constructed temporary levees at Fargo, Breckenridge, Wahpeton, Moorhead, Halstad, Grand Forks, East Grand Forks, and a number of smaller communities located in the main stem subbasin. These emergency efforts have afforded protection for a particular flood event but are not considered adequate for permanent protection.

5. Under Section 205 of the 1948 Flood Control Act, the Corps completed in 1978 a local flood protection project consisting of an earthen levee about 14,600 feet long, a reinforced concrete floodwall about 1,000 feet long, and related interior drainage facilities at Pembina, North Dakota. This project provides the Town of Pembina flood protection from both Red and Pembina River floods. Levees were designed to protect against a Red River discharge of 151,000 cfs, which is a 0.67 percent chance flood.

6. Under the authority of Public Law-566, the St. Thomas-Lodema Watershed Project in Pembina County, North Dakota was authorized in 1965. This project is estimated to be completed in 1980 and includes 39.17 miles of channel improvements. When completed, this project will reduce average annual flood damages in this 98-square-mile watershed by about 72 percent. Construction of this project is being sponsored by the SCS in cooperation with local interests.

7. The Midland-Drayton Watershed Project, another PL-566 project, in Pembina County, North Dakota was authorized in 1968. This project, which has been completed, includes 14.1 miles of channel improvements designed to convey the eight-year frequency runoff and will reduce average annual flood damages in this 84-square-mile watershed by 71 percent. The SCS in cooperation with local interests sponsored this project.

8. The Joe River Watershed Project in Kittson County, Minnesota is another PL-566 project sponsored by the SCS and local interests. The project was authorized in 1962 and completed in 1973. Structural measures for flood control included 26.5 miles of channel improvement which will provide 10 percent (10-year) flood protection for this 86-square-mile watershed.

9. Since 1975, farmers have constructed levees along both banks of the Red River that have protected farm fields from being inundated by floods. These levees are in the vicinity of Oslo, Minnesota. The Minnesota levees have a total length of about 36 miles within the limits of river mile 236 to 282. The North Dakota levees have a total length of about 19 miles within the limits of river mile 247 to 289.

10. Numerous emergency levees have been constructed in various cities and towns during floods. Many of these have been left in place and provide some degree of flood protection in each community.

Nonstructural Measures

Nonstructural flood control measures are measures that reduce or eliminate flood damages through procedures that involve little, if any, construction efforts. The major types are flood warning and forecasting services, floodplain zoning and insurance, flood proofing, and evacuation. These measures are primarily applicable to urban areas.

The towns in the subbasin participate in the Red River Valley flood warning system. The flood warning system for the Red River Valley is a cooperative network organized by the National Weather Service in Fargo, North Dakota. Fifty volunteers throughout the basin report to the National Weather Service on a weekly basis during winter and fall and on a daily basis during spring and summer. The reportage covers all precipitation of 0.1 inch or more, including amounts of snow and water equivalent. This information is transmitted to the River Forecast Center in Minneapolis, Minnesota, where it is run through a computer system to determine probable flood stages. The predictions are then transmitted to the National Weather Service in Fargo, which releases them to the public through the news media. Communities are then able to engage in emergency actions to protect themselves from flood damages. Contacts with local officials indicate that the flood warning system works quite well in the subbasin.

On the Minnesota side of the subbasin, the cities of Breckenridge, Moorhead and East Grand Forks have adopted floodplain zoning ordinances and participate in the Federal flood insurance program. These three Minnesota cities also enforce building codes and subdivision regulations for floodplain areas. In addition, East Grand Forks has undertaken the relocation of some structural improvements in the floodplain. Halstad, Hendrum and Perley have adopted floodplain regulations, participate in the Federal flood insurance program and enforce subdivision regulations for floodplain areas. Oslo and St. Vincent both participate in the Federal flood insurance program. Clay, Kittson, Marshall, Norman, Polk, and Wilkin counties all participate in the Federal flood insurance program. Clay, Norman and Wilkin counties also have adopted floodplain zoning ordinances, and Clay and Wilkin counties enforce subdivision regulations in floodplain areas. Clay County has also undertaken the relocation of certain structural improvements out of floodplain areas.

On the North Dakota side of the subbasin, information is not as complete. However, Federal policies require and the State of North Dakota encourages the adoption of floodplain zoning ordinances and participation in the flood insurance program.

There are other types of measures that could be implemented in the subbasin to reduce flood damages but that are not directly applicable to urban areas. These measures would include such things as land treatment programs, use of present drainage ditches for floodwater storage, and use of natural areas for reversion to water retention use. Land treatment is used by some farmers in the subbasin, but the Soil Conservation Service (SCS) has not been called upon to undertake a large-scale program. Present drainage ditches are not used for floodwater storage, and no plans have been developed for future use.

Information on natural storage areas and potentialities for increased storage is limited. Indications are, however, that wetlands play an important role in controlling runoff, especially in combination with good land treatment practices. Valves on storage have averaged about twelve inches per surface-acre of wetlands and have ranged to four times that amount (Cernohous, 1979). The location, type and amount of wetland habitat within the watershed area (or subbasin) is important: statistical studies indicate that in certain situations if a watershed has 15 percent of its area in wetlands or lakes, peak floods will be 60 to 65 percent lower than they would be in the absence of the wetland/lake area; if wetlands or lakes occupy 30 percent of the watershed, there will be a further reduction in flood peaks up to about 75 or 80 percent (Scientists' Report, National Symposium on Wetlands, 1978).

Adequacy of Existing Measures

The present one percent (100-year) floodplain along the Main Stem comprises about 663,000 acres or about 1,036 square miles. In addition to the flooding of valuable farmland, 10 communities in Minnesota and 16 communities in North Dakota suffer extensive damages during major floods. Present flood damages include both tangible and intangible losses. Tangible losses suffered during floods include agricultural damages; structures damaged by inundation; damage to utilities and transportation

facilities; flood fighting costs; business losses; and increased living and operating expenses during floods. Intangible expenses include the threat to human life, human misery during a flood, disruption of normal community activities and potential health hazards.

The Main Stem channel generally can contain the 30 percent (3.3-year) frequency flood with the present tributary reservoirs. The channel has greater capacity in some reaches, but in some it has slightly less. Most communities along the RedRiver are not adequately protected for major floods and suffer extensive damages as well as the considerable expense involved in flood fights. The agricultural levees along the Main Stem have been instrumental in preventing agricultural losses. However, the Corps of Engineers acts only as a technical advisor and has no authority to regulate the construction of these levees, which has resulted in the following problems:

1. The existing levee system is effective for a flood with a magnitude in the range of 20 to 10 percent, but a lack of technical assistance in the design and construction of the levees has resulted in a levee system which at best can be rated as only fair. Sections of the levees on occasion have either failed or been overtopped.

2. A serious potential exists for these levees to have a significant adverse impact on flood stages and velocities. This condition possibly could cause international problems and could adversely affect flood control projects at Oslo and Grand Forks. The 1978 flood crest at Oslo was 1.0 foot higher than it would have been were there no agricultural levees. Also, the levees could cause serious erosion, which would threaten streambanks, bridge crossings and riverside communities.

3. The present locations of these levees violate the setback requirement of the levee criteria recently agreed on by the States of Minnesota and North Dakota which states that the setback of agricultural levees shall be such as not to increase the elevation of the one percent (100-year) frequency flood profile more than one-half foot.

Under the present limited flood protection available, all tangible and intangible losses would continue on an increased scale in the future. Changes in type and extent of flood damages would result from community renewal programs, land use shifts, and changes in agricultural practices.

Floodplain management programs would help reduce future flood losses; however, recurring flooding along the Main Stem will continue to be a serious problem, and additional measures (both structural and nonstructural) will be required to significantly reduce flood damages within the subbasin.

VII. CRITERIA AND PLANNING OBJECTIVES

VII. CRITERIA AND PLANNING OBJECTIVES

Floodplain Management Criteria

Technical, economic, and environmental criteria must be considered when formulating and evaluating alternative floodplain management measures for the subbasin.

The technical criteria used in formulating and evaluating alternatives for this report consisted of the application of appropriate engineering standards, regulations, and guidelines.

Economic criteria entailed the identification and comparison of benefits and costs of each measure. Tangible economic benefits must exceed costs; however, in certain instances, considerations of appropriate gains in the other accounts (environmental quality, social well-being and regional development) could alter this requirement. All alternatives considered are scaled to a design which optimizes benefits. Annual costs and benefits are based on an interest rate of 7 1/8 percent and price levels and conditions existing in October 1979. A 50-year amortization schedule is used for the features considered.

Environmental considerations call for the formulation of measures that minimize objectionable or adverse environmental effects and maximize environmental benefits. Also, limited consideration was given to modifications based on coordination with state and Federal agencies, local interests, and citizen groups.

Planning Objectives

The primary planning objective of this study was to contribute to flood reduction needs in the subbasin and thereby provide protection for or reduction of flood losses. In conjunction with this economic objective, the study attempted to develop contributions to the environmental quality of the subbasin.

The development of planning objectives involved a broad-range analysis of the needs, opportunities, concerns, and constraints of the subbasin from the information that was available. On the basis of this analysis of the problems, needs, and desires that could be identified, the following planning objectives were established:

1. Contribute to protection from and prevention, reduction, or compensation of flood losses for the flood prone areas of the subbasin during the period of analysis.

2. Contribute, to the maximum extent possible, to the preservation of the quality of the existing riverine environment and enhance the environmental potential of the subbasin as a whole.

3. Contribute to the enhancement of water-based recreational opportunities throughout the subbasin.

4. Contribute to the improvement of water quality in the Red River and other rivers and streams within the subbasin.

5. Contribute to the improvement of water supply especially for the major population centers of the subbasin.

6. Contribute to the reduction of wind and water erosion throughout the subbasin.

7. Contribute to the developing trend toward increased irrigation throughout the subbasin.

8. Contribute to the reduction of wastewater management problems, particularly insofar as they relate to water quality.

9. Contribute to the development of small hydroelectric installations on the Red River.

VIII. FORMULATION OF ALTERNATIVE MEASURES

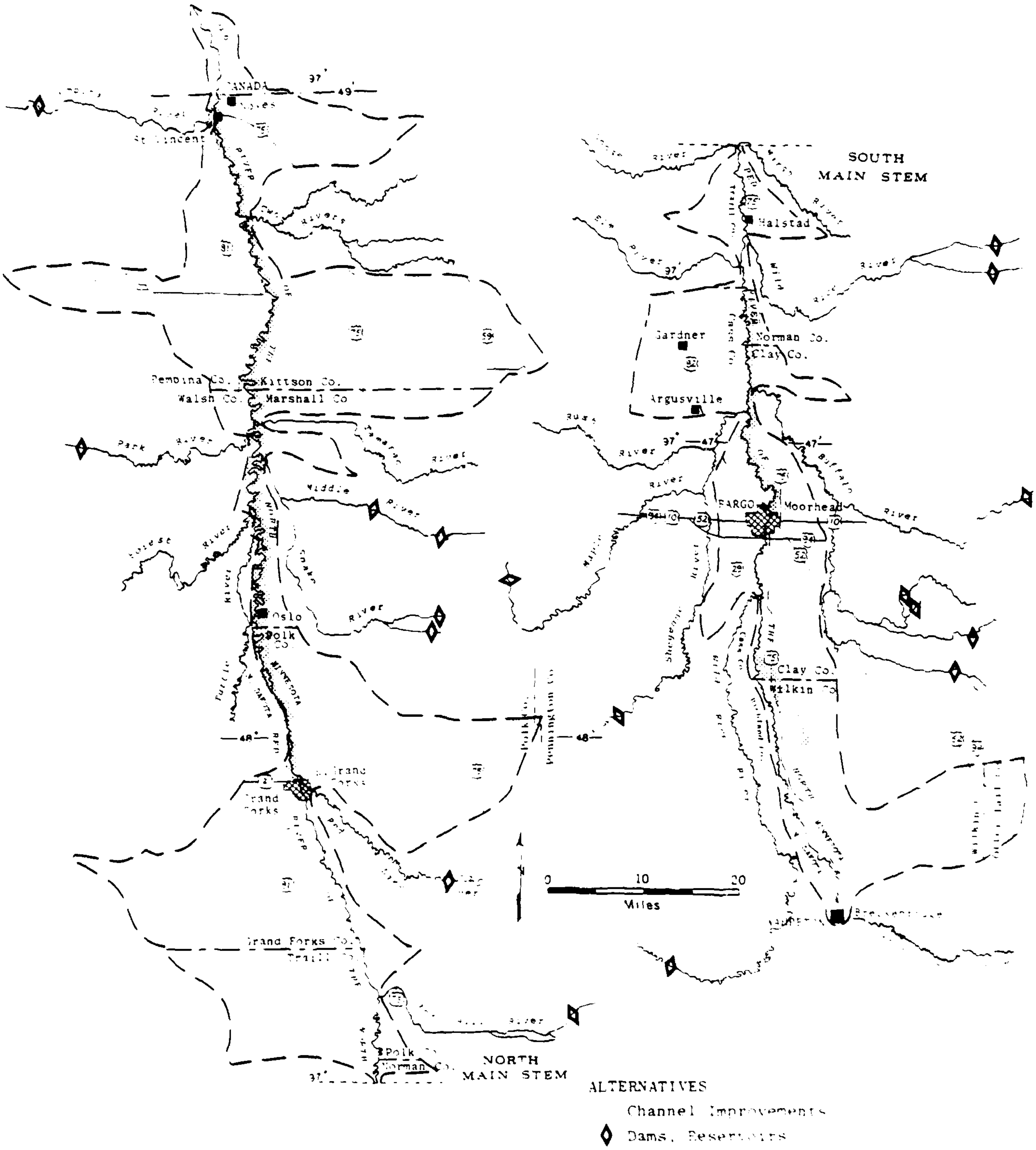
VIII. FORMULATION OF ALTERNATIVE MEASURES

This section includes discussions of management measures identified from previous studies and investigations and measures that have been formulated in this study to meet the resource management objectives. In the identification and formulation of alternative measures, prime consideration was given to the resolution of flooding problems. Measures to satisfy the other planning objectives were considered exclusively as components of the flood control measures.

The following structural measures, which are illustrated in Figure VI, were devised in response to the flood control planning objective:

1. Agricultural levees constructed in compliance with the existing criteria and agreement between the states of North Dakota and Minnesota along each side fo the Main Stem channel between the International Boundary and Grand Forks, North Dakota and at random locations between Grand Forks and Wahpeton, North Dakota. The total length of levees is 222 miles in the northern reach and 200 miles in the southern reach. These measures would reduce the one percent floodplain by 392,000 acres and provide one percent flood protection for all unprotected urban areas along the Main Stem. The average annual area flooded would be reduced from 43,722 acres to 33,516 acres in the reach north of Grand Forks and from 17,003 acres to 13,034 acres in the reach south of Grand Forks. The implementing agency would be the Corps of Engineers.

2. Improve approximately 196 miles of the Main Stem channel to contain the 10 percent (10-year) flood. Included in this measure are two reaches; the first is 151 miles long, extending from the International Boundary to just south of Grand Forks (river mile 155 to river mile 306), and the second is 46 miles long, from just north of Perley, Minnesota to Fargo, North Dakota (river mile 400 to river mile 445). This measure provides 10 percent flood protection for the entire Main Stem floodplain, which is about 196,000 acres, and the urban areas of Drayton and Bowesmont in North Dakota, and Robbin and East Grand Forks in Minnesota. This measure also would reduce the one percent floodplain by 71,000 acres. The average annual area flooded would be reduced from 43,722 acres to 16,650 acres in the reach north of Grand Forks and from 17,003 acres to 6,440 acres in the reach south of Grand Forks. The implementing agency would be the Corps of Engineers.



Source: Gulf South Research Institute.

Figure VI. ALTERNATIVE FLOOD CONTROL MEASURES

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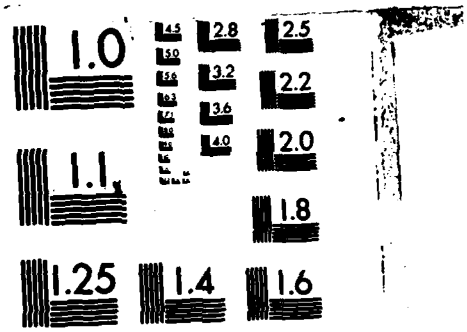


MICROCOPY RESOLUTION TEST CHART
NATIONAL BUREAU OF STANDARDS-1963-A

3. Storage reservoirs on the tributaries of the Main Stem to provide an additional 806,200 acre-feet of flood storage. Table 18 is a tabulation of the pertinent data for these reservoirs. The locations of these reservoirs are shown on Figure VI. Table 19 lists the approximate effects of these reservoirs on stream flow conditions at seven locations on the Main Stem. This measure would reduce the one percent floodplain by 66,000 acres and provide about 24 percent (4.2-year) flood protection for the Main Stem floodplain, including urban areas. The average annual area flooded would be reduced from 60,725 acres to 43,025 acres. The implementing agencies would be the Corps of Engineers and the SCS.

4. Flood damage reduction measures and land treatment measures in the Comstock Coulee Watershed in Clay and Wilkin Counties, Minnesota. This alternative consists of 32 miles of channel improvements, ten stabilization structures, new ditch construction, repairing existing ditches and drains, and land treatment measures. These improvements would provide about 10 percent (10-year) flood protection for this 105 square mile watershed. The implementing agency would be the SCS.

5. Construct new levees and/or floodwalls, interior drainage and pumping facilities, road raises and closures, and improve existing levees to provide flood protection for 15 cities and towns in Minnesota and North Dakota. A listing of these communities is shown in Table 1. Two of these communities, Argusville, North Dakota and Halstad, Minnesota, have authorized flood control projects. The implementing agency would be the Corps of Engineers or local interests.

6. Construct farmstead levees around individual farmsteads in the one percent (100-year) floodplain.

7. The use of diversion channels was another structural measure considered to relieve Main Stem flooding. Consideration was given to diverting portions of channel flow at 11 locations along the Main Stem and its tributaries. A preliminary analysis revealed that eight of these were not viable alternatives because either the streams did not have sufficient flow to affect Red River floodcrests, or they did not provide flood protection for urban areas, or they would aggravate upstream flood conditions. The remaining three locations appeared to have some viability and were analyzed in more detail. The results of this analysis are as follows:

   a. Diverting a portion of flow from the Red Lake River to Red River via Grand Marais Creek near Fisher, Minnesota. The Red Lake River channel at this location has a

Table 18

TRIBUTARY RESERVOIR DATA

Stream	State	Name	Implementing Agency	Number of Reservoirs	Flood Storage (ac-ft)	Cost ($1,000)
Pembina	North Dakota	Pemblier North Branch	COE	1	128,000	35,178
Park	North Dakota	Park River Watershed	SCS	1 or more	14,400	1,145
Maple	North Dakota	Enderlin	COE	1	47,000	18,330
Sheyenne	North Dakota	Kindred	COE	1	194,000	54,000
Wild Rice	North Dakota	Mantador	COE	1	26,100	12,737
Middle	Minnesota	--	COE	2	3,800	689
Snake	Minnesota	Snake River Watershed	SCS	Multiple	9,800	862
Red Lake	Minnesota	Huot	COE	1	205,000	42,480
Wild Rice	Minnesota	Twin Valley	COE	1	44,700	21,366
Buffalo	Minnesota	Hawley	COE	1	51,000	51,000
Buffalo	Minnesota	South Buffalo Watershed	SCS	3	7,800	689
Sand Hill	Minnesota	Winger	COE	1	25,000	11,500
Wild Rice	Minnesota	--	SCS	Multiple	14,600	1,161
TOTAL					806,200	251,137

Table 19

EFFECT OF TRIBUTARY RESERVOIRS ON MAIN STEM FLOODING

Location	1 Percent (100 Year) Discharge (cfs) Existing	1 Percent (100 Year) Discharge (cfs) Revised	1 Percent (100 Year) Stage Reduction	10 Percent (10 Year) Discharge (cfs) Existing	10 Percent (10 Year) Discharge (cfs) Revised	10 Percent (10 Year) Stage Reduction	30 Percent (3.3 Year) Discharge (cfs) Existing	30 Percent (3.3 Year) Discharge (cfs) Revised	30 Percent (3.3 Year) Stage Reduction
Emerson	124,000	102,000	0.8'	52,000	47,000	1.1'	29,000	26,500	1.8'
Dryaton	108,000	97,000	0.3'	47,000	42,500	0.8'	28,000	24,000	1.8'
Oslo	105,000	92,000	0.3'	46,000	39,500	0.8'	25,000	21,500	2.2'
Grand Forks	102,000	85,000	1.9'	45,000	36,000	2.7'	23,500	19,500	2.3'
Halstad	56,000	47,000	0.8'	24,000	20,000	3.8'	14,500	12,500	2.2'
Fargo	33,000	32,000	0.2'	11,400	9,200	2.7'	6,200	5,000	2.1'
Wahpeton	---No Change---								

capacity of approximately 9,000 cfs, with a one percent discharge of about 34,000 cfs and a 10 percent discharge of about 16,000 cfs. Improving the Grand Marais Creek channel to contain flows in excess of 9,000 cfs would not be economically viable. Constructing an overflow at this location to route excess Red Lake River flow into the existing creek channel would flood a substantial area in the Grand Marais Creek floodplain, which is not desirable. Based on these findings, diverting portions of Red Lake River flow to Red River via Grand Marais Creek is not a viable alternative.

b. Diverting Red River flow through the Marais River from river mile 247 to 273.5. This stream lies entirely within the Red River one percent floodplain and carries some excess Red River flow. Flooding begins when the capacities of both channels are exceeded. Modifying the Red River channel to contain the specified flood would be a more desirable alternative than improving the Marais River flow to carry added Red River flow.

c. Diverting the Wild Rice (North Dakota) to junction with the Red from river mile 470 to 523. The existing Red River channel in this reach can contain the 10 percent flood. Diverting part of Red River excess flow into the Wild Rice channel would reduce the one percent floodplain somewhat in the problem area between river mile 465 and 485 at low Wild Rice stages, but it would have no effect during high stages. Extensive Wild Rice channel modifications, which lack economic feasibility, would be required to significantly reduce flooding caused by floods of less frequency than 10 percent.

Engineering Methodology

The structural alternatives considered in this analysis are based on information extrapolated from prior studies and reports, data furnished by the Corps of Engineers, data furnished by the Soil Conservation Service (SCS), existing streamflow data, and U.S.G.S. quadrangle maps. Where there were data gaps, additional information was developed from the aforementioned sources and from data developed in the analysis of the tributaries. The following is a discussion of the methodology used in developing each structural alternative measure.

1. Agricultural Levees

The agricultural levees are based on one percent (100-year) flood protection and are set back to satisfy the recently devised Minnesota-North Dakota agricultural levee criterion stipulating that the one percent

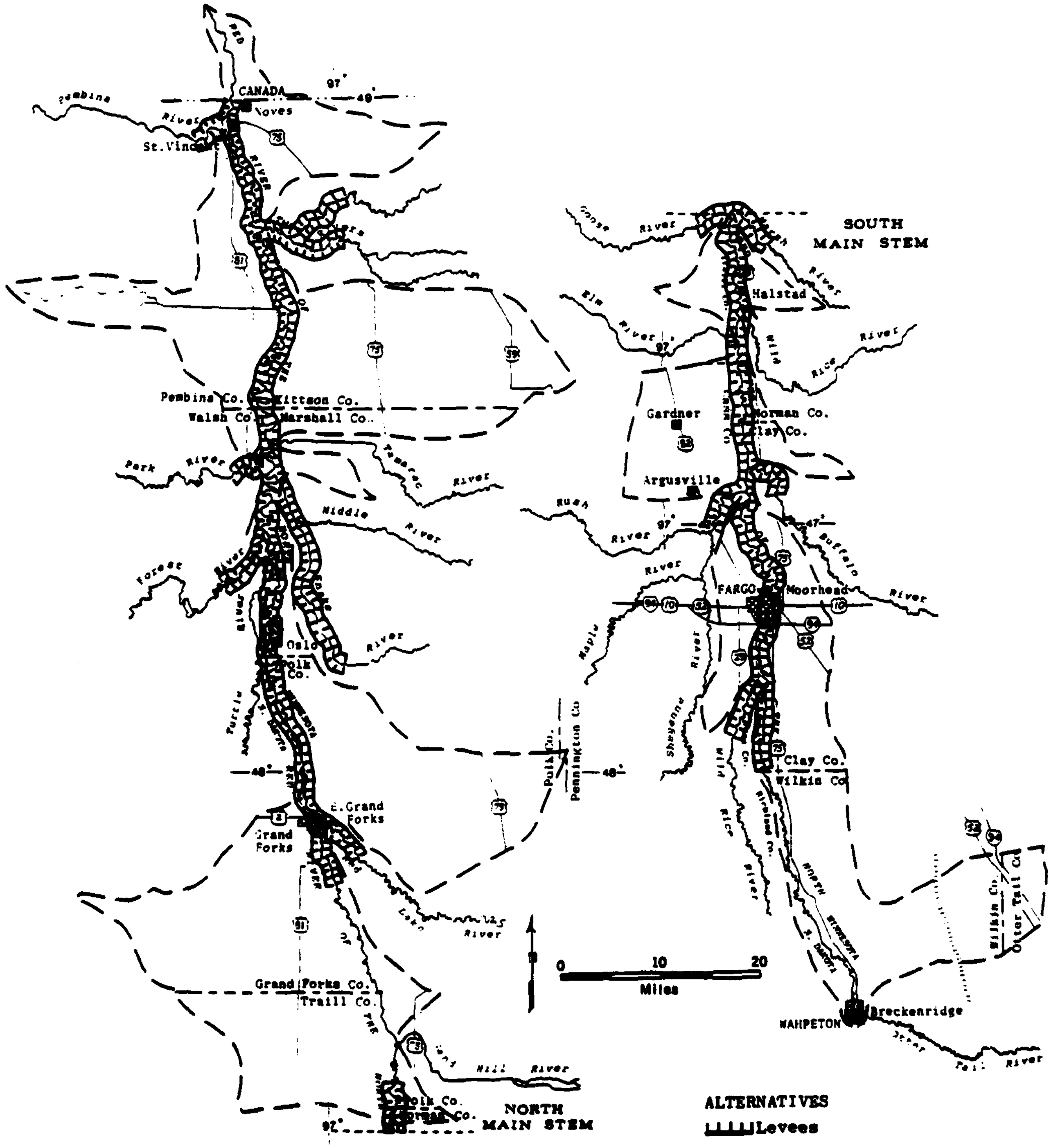
flood stage should not be increased more than 0.5 feet. An area flooded vs. discharge curve for the Red at Emerson, Manitoba (international boundary) was developed from information obtained from post flood reports. An area flooded vs. chance of occurrence in one year was plotted for the present one percent floodplain and the one percent floodplain with the levees in place. These curves were based on the entire Main Stem floodplain in the United States and were used to estimate average annual damages and benefits. Discharge vs. frequency of occurrence curves and the area floded vs. discharge curve were used to develop the area flooded vs. chance of occurrence in one year curves. Main Stem cross-sections furnished by the Corps of Engineers were used in the setback analysis. Where cross sections were inadequate, additional data was obtained from quadrangle maps.

2. Channel Modification

The capacity of the existing Main Stem channel was analyzed at various locations to determine the extent of flooding caused by 10 percent (100-year) and 30 percent (3.3-year) frequency floods. Existing channel capacities at these locations were obtained from prior studies and reports. The existing channel generally can handle the 30 percent flood, but extensive enlargement would be required for a 10 percent channel capacity. After this was determined, an area flooded vs. chance of occurrence in one year curve for the Main Stem floodplain at the international border was plotted for the 10 percent channel measure, which was used, in conjunction with the present condition curve, to estimate average annual damages and benefits.

3. Tributary Reservoirs

The locations and volumes of the reservoirs used in this analysis were either obtained from prior studies and reports or from the subbasin analyses. A one percent discharge vs. flood volume (in acre-feet) was plotted from data obtained from prior studies and reports and from flood volume data supplied by the Corps of Engineers. This curve was for the present condition, which included all existing Corps of Engineers, SCS and other flood control reservoirs. Using this curve and other stream



Source: Gulf South Research Institute.

Figure VII. ALTERNATIVE LEVEES

data for selected points, frequency of occurrence vs. flood volume curves were plotted for the selected points, which permitted estimating flood volume for various frequencies under present conditions. The next step was to plot revised frequency of occurrence vs. flood volume curves at the selected points by taking into account the additional reservoir storage at that location. The revised volumes for various frequencies could then be converted to discharges and revised frequency of occurrence vs. discharge curves plotted. Revised discharges for the one, 10 and 30 percent floods were then compared with the present discharges to estimate the flood discharge reduction at each location for these frequencies. The effect of the reservoirs on flood stages at the selected locations could then be estimated using the revised discharges and rating curves. The last step was to plot an area flooded vs. chance of occurrence in one year curve at the international border to estimate average annual damages and benefits.

4. Comstock Coulee Watershed

This measure was developed from information obtained from an application for planning assistance. Capital costs and benefits per acre of watershed improvement were developed from completed watershed improvement projects in the Red River Basin.

5. Flood Protection For Urban Areas

Flood protection measures for some urban areas were developed from prior studies and reports. In communities where there were no data available, measures were based on similar conditions in other communities. Quadrangle maps and available stream flow data were used to estimate the extent of flood protection required in comunities where no prior studies have been conducted.

6. Farmstead Levees

The farmstead levee alternative is based on data obtained from studies by the Corps of Engineers. Capital costs are based on the assumption that individual owners would construct their own levees.

7. <u>General</u>

This analysis of the effect of the various structural flood control measures on Main Stem flooding has been based on somewhat limited data. Streamflow and hydrological data is somewhat limited, and there were gaps in the quadrangle map coverage. Where additional streamflow data was required, additional data were developed based on available data and the contractor's experience and judgement. Where there were gaps in the 1:24,000 scale quadrangle maps, 1:25,000 scale maps were used. The channel modification scheme was analyzed on the basis of 15 Main Stem cross-sections furnished by the Corps of Engineers. There were discrepancies between the elevations shown on the cross-sections and those on the quadrangle maps. The locations of some of the cross sections were in question, which could have been the reason for the elevation discrepancies. Also, it was assumed that present bridge openings could pass the 10 percent flow. Agricultural levees were based on utilizing seepage berms rather than relief wells. The cost of pumping facilities for agricultural levees and in some urban areas was based on utilizing portable pumps. The pumping capacity for the agricultural levee measures was based on pumping the 20 percent (five-year) flood.

Capital costs are October, 1979 price levels. For some measures, capital costs from prior studies and reports were updated to October, 1979 price levels using <u>Engineering News-Record</u> cost indexes. For other measures, capital costs were estimated using October, 1979 unit construction costs. All capital costs estimates contain items for a construction contingency and for engineering. The construction contingency is 25 percent of the estimated construction cost. The engineering cost is 20 percent of the total construction cost, including contingency items.

<u>Nonstructural Measures</u>

Among the nonstructural measures considered in previous Corps reports were flood warning and forecasting services, emergency protection, permanent floodplain evacuation, and flood proofing. The conclusions of these reports with respect to the various nonstructural measures are discussed in the following paragraphs.

Floodplain regulation and flood insurance are currently required by Federal policies and the State of Minnesota and encouraged by the State of North Dakota. Floodplain regulation consists primarily of regulating new development in floodplain areas, thereby reducing or eliminating future flood damages. Flood insurance does not prevent or reduce damages to existing structures, but assists in reimbursing owners of existing developments for flood losses.

Unsubsidized crop insurance is available through the U.S. Department of Agriculture Federal Crop Insurance Program, which covers all natural disasters including floods. However, actual crop damages could be reduced only to the extent that intensive farming practices would be discouraged over long periods of time in the floodplain. Because of the highly productive nature of floodplain farming, it is very doubtful that any long-term shifts away from the intensive farming of floodplain areas would occur.

Flood warning and forecasting services in conjunction with emergency protection measures have been used with reasonable success. Floods resulting from snowmelt usually occur in a fashion which allows the necessary time for the construction of emergency protection works. However, the larger the magnitude of the flood, the greater the structural stability problems caused by underlying soil conditions. In addition, the greater danger of failure would increase the potential for loss of life. Emergency protection measures would continue to inconvenience residents of the floodplain and would disrupt the biological system and scenic quality of the area.

Development of a basin-wide drainage plan based on sound hydrology and hydraulic analyses and a thorough understanding of the economic, environmental and social consequences of such a plan would assist in orderly and rational implementation of future drainage projects. The development of an acceptable and implementable drainage plan is dependent upon a more complete understanding of the relationship of drainage and downstream flood flows. A coordinated approach at the county level would be required in order to develop and implement a basin-wide drainage plan.

Land use planning emphasizes the conservation and productive use of the land resources. Effective achievement of this goal might require shifting control from local authorities to regional or higher levels of government.

Public or private purchase of lands in the floodplain to establish greenbelts with some form of floodplain regulations on building in these greenbelts should be considered. The narrow band of trees bordering each side of the river provides attractive locations for residential development, which has already begun to occur in the Grand Forks-East Grand Forks and Fargo-Moorhead areas. Even though the trees have been retained, the nature of the woodland has changed. Many of these residential developments are flood prone and represent increases in potential flood damages in the subbasin. These narrow bands of trees along side the river help retain snowfall, moisture and erosion. However, they have no noticeable effect on flood stages and flood damages in the immediate area. Preservation of these areas would provide benefits as recreation corridors, fish and wildlife habitat, and scenic areas.

A program could be established by state or Federal interests to provide financial incentives to encourage farmers to retain water on wetlands. This program could only be considered as supplemental to other programs. It might help reduce flood flows in some areas, but would have to be widely accepted and used before any effects would be felt downstream.

Permanent evacuation of flood prone areas would consist of the acquisition of land, relocation of improvements, and resettlement of the population, ultimately resulting in the conversion of land use to a state less susceptible to flood damages.

Flood proofing consists of a combination of structural changes and adjustments to properties subject to flooding for the purpose of reducing or eliminating flood damages. Although best applied to new construction, it can be applied to existing structures in some instances.

The operation of existing reservoirs, particularly on the Sheyenne and Park Rivers, North Dakota and the Ottertail and Red Lake Rivers in Minnesota should be thoroughly reviewed. Present operation of these reservoirs is based on maintaining full pools each summer for water supply

uses and having the pools drawn in the winter for control of spring runoff. Historically, the drawdown of reservoir pool levels has been increasing in order to provide additional storage capacity for spring floods. In some cases this drawdown is in excess of 50 percent of total storage capacity. Given the storage capacities of these reservoirs and the phenomenal volume of flood flows, certainly drawdowns to lower levels would not provide significantly greater reductions in flood flows. Modifications in release rates and drawdowns might be beneficial for some of the smaller floods, but the capability of existing reservoirs to reduce flood flows for the larger floods is severely limited. Effects on fisheries, water quality, downstream streambank erosion, and other factors may be more directly influenced by revised management of existing reservoirs. It appears that any changes in the operation of the existing reservoirs would have little effect on flood levels along the Red River Main Stem.

The adoption and enforcement of a comprehensive water management law to control drainage, encourage floodplain zoning, and regulate Federal, State, and local water resource projects within the entire Red River Basin should be encouraged.

Remaining wetland areas should be purchased for environmental preservation and flood damage reduction purposes. The land could be acquired through fee title or easements, and only existing wetlands would be considered in order to minimize the impacts on agricultural production and landowners.

The preceeding discussion summarizes the results of Corps of Engineers investigations. In addition to nonstructural measures discussed in Corps reports, there is an opportunity for the use of land treatment measures throughout the subbasin that would help to contain water on land as well as reduce erosion damages. Other measures would include, but not be limited to, water retention in existing ditches, preservation of natural retention areas, minimum fall tillage, on-farm retention of runoff and maintenance of grassed waterways. Wetland restoration could also be considered, where appropriate, for water retention.

IX. ASSESSMENT OF ALTERNATIVES

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Economic Assessment

Topography is an important influencing factor that contributes to tributary floods in the Red River Valley. Stream slopes become milder, and channel capacities decrease in the flat valley area, where floodwaters escape the channel and move overland, inundating vast acreages of farmland and entire communities. Snow and ice accumulate in stream channels and ice jams, particularly at river bridges and constricted reaches, and often increase upstream river levels, causing localized flooding. Within channel banks, standing and fallen trees, brush, and sediment deposition reduce flow carrying capacities.

An important element which often influences the magnitude of Main Stem floods is the northward flow of the Red River. In the spring, rising temperatures progress slowly from the southern headwater portion of the basin north toward Canada. Spring floods result from the melting of snow beginning in the headwaters and flowing into areas often still blocked by winter ice cover. The channel ice causes backwater and localized increases in floodwater.

The economic effects of the flood control alternatives for the subbasin along with their costs and benefits are presented in Table 20. Since no information was available on weighted damages per acre for the subbasin, a figure was drawn from the Phase 1, General Design Memorandum for Flood Control and Related Purposes, Sheyenne River, North Dakota.

Alternative one consists of agricultural levees constructed in accordance with State criteria along each side of the Main Stem channel between the International Boundary and Grand Forks, North Dakota. The total length of levees is 222 miles. This measure would provide one percent flood protection for all unprotected urban areas along this northern portion of the main stem. Average annual area flooded would be reduced from 43,722 acres to 33,516 acres. Economic evaluation of this alternative yielded a benefit/cost ratio of 0.67.

Alternative two consists of agricultural levees constructed in accordance with State criteria along the Main Stem channel at random locations between

Table 20

ECONOMIC EVALUATION OF ALTERNATIVES

Alternatives	Acres Protected	Average Annual Acres	Capital Costs	Average Annual Costs	Average Annual Rural Benefits	Average Annual Urban Benefits	Total Average Annual Benefits	B/C Ratio
1. Agricultural Levees from Grand Forks to Canadian Border (1% Flood)	282,240	9,492	$ 59,456,000	$ 4,376,600	$ 809,600	2,129,800	2,939,400	0.67
2. Agricultural Levees from Breckenridge/Wahpeton to Grand Forks (1% Flood)	109,760	1,691	31,412,000	2,313,700	314,800	1,114,300	1,429,100	0.62
3. Channel Improvements from Grand Forks to Canadian Border (10% Flood)	51,120	25,260	180,234,000	13,267,000	2,154,400	1,902,200	4,056,600	0.31
4. Channel Improvements from Perley to Fargo (10% Flood)	19,880	9,824	13,056,000	961,100	812,300	747,400	1,560,100	1.62
5. Tributary Reservoirs (24% Flood)	65,000	16,461	251,137,000	18,486,200	1,404,000	1,683,500	--	0.17
6. Comstock Coulee Watershed (10% Flood)	--	-	1,695,000	124,800	122,000*	--	--	0.98
7. Flood Protection at Noyes, Minnesota (1% Flood)	--	--	110,000	8,100	--	7,800	7,800	0.96
8. Flood Protection at St. Vincent, Minnesota (1% Flood)	--	--	570,000	42,000	--	33,500	33,500	0.80
9. Flood Protection at Bowesmont, North Dakota (1% Flood)	--	-	171,000	12,600	--	16,300	16,300	1.29
10. Flood Protection at Robbin, Minnesota (1% Flood)	-	--	100,000	7,400	--	10,000	10,000	1.35
11. Flood Protection at Drayton, North Dakota (1% Flood)	--	-	702,000	51,700	--	30,600	30,600	0.59
12. Flood Protection at East Grand Forks, Minnesota (1% Flood)	--	-	10,751,000	791,400	--	715,500	715,500	0.90
13. Flood Protection at Halstad, Minnesota (1% Flood)	--	--	1,385,000	102,000	--	44,000	44,000	0.43
14. Flood Protection at Perley, Minnesota (1% Flood)	--	--	120,000	8,800	--	37,000	37,000	4.20
15. Flood Protection at Breckenridge, Minnesota (1% Flood)	--	--	2,106,000	155,000	--	114,400	114,400	0.74
16. Flood Protection at Argusville North Dakota (1% Flood)	--	--	213,000	15,700	--	23,900	23,900	1.52
17. Flood Protection at Brooktree, Park, North Dakota (1% Flood)	--	--	65,000	4,800	--	28,200	28,200	5.88
18. Flood Protection at Harwood, North Dakota (1% Flood)	--	--	120,000	8,900	--	99,800	99,800	11.21
19. Flood Protection at Rivertree, North Dakota (1% Flood)	--	--	65,000	4,800	--	60,300	60,300	12.56
20. Flood Protection at Wahpeton, North Dakota (1% Flood)	--	--	1,756,000	129,300	--	101,900	101,900	0.79
21. Farmstead Levees (Per Levee)	--	--	5,600	400	840	--	840	2.10

*Includes and urban benefits.

Source: Gulf South Research Institute.

Grand Forks and Wahpeton, North Dakota, and Breckenridge, Minnesota. The total length of levees is 200 miles. This measure would provide one percent flood protection for all unprotected urban areas along this southern portion of the Main Stem. The average annual area flooded would be reduced from 17,003 acres to 13,034 acres. Economic evaluation of this alternative yielded a benefit/cost ratio of 0.62.

Alternative three consists of channel improvements to approximately 151 miles of the Main Stem channel from the International Boundary to just south of Grand Forks (river mile 155 to river mile 306). These improvements would allow the channel capacity to contain the 10 percent (10-year) frequency flood. The average annual area flooded would be reduced from 43,722 acres to 16,650 acres. Economic evaluation of this alternative yielded a benefit/cost ratio of 0.31.

Alternative four consists of channel improvements to 46 miles of the Main Stem channel from just north of Perley, Minnesota, to Fargo, North Dakota (river mile 400 to river mile 445). These improvements would permit the Main Stem channel to contain the 10 percent (10-year) frequency flood. Average annual area flooded should be reduced from 17,003 acres to 6,440. Economic evaluation of this alternative yielded a benefit/cost cost ratio of 1.62.

Alternative five consists of storage reservoirs on the tributaries of the Main Stem to provide an additional 806,200 acre-feet of flood storage. This measure would reduce the one percent floodplain by 66,000 acres and provide about 24 percent (4.2-year) flood protection for the Main Stem floodplain, including urban areas. The average annual area flooded would be reduced from 60,725 acres to 43,025 acres. Economic evaluation of this alternative yielded a benefit/cost ratio of 0.17.

Alternative six consists of flood damage reduction measures and land treatment measures in the Comstock Coulee Watershed in Clay and Wilkin counties, Minnesota. This alternative included 32 miles of channel improvements, 10 stabilizations structures, new ditch construction, repairing existing ditches and drains, and land treatment measures. These improvements would provide about 10 percent (10-year) frequency flood protection for this 105 square mile watershed. Economic evaluation of this alternative yielded a benefit/cost ratio of 0.98.

Alternatives seven through twenty consist of constructing new levees and/or floodwalls, interior drainage and pumping facilities, road raises and closures, and improving existing levees to provide flood protection for 14 cities and towns in Minnesota and North Dakota. Two of these communities, Argusville, North Dakota and Halstad, Minnesota have authorized flood control projects. Economic evaluation of these alternatives yielded benefit/cost ratios ranging from 0.43 at Halstad, Minnesota to 12.56 at Rivertree, North Dakota.

Alternative 21 consists of the construction of levees around individual farmsteads in floodprone areas. The levees would provide protection against a one percent (100-year) frequency flood. Economic evaluation of this alternative yielded a benefit/cost ratio of 2.10.

Impact Assessment

The measures recommended for consideration in the subbasin include control structures and channel improvements along the Red River of the North. A generalized assessment of the effects on the resource elements that can be expected if structural measures were to be implemented is presented in Table 21.

Channel Modifications and Diversion Channels

All or portions of two channel improvements and three diversion canals would yield moderately beneficial social and economic effects, some moderate to maximally adverse biological effects, and short-term adverse but long-term limited beneficial results for water quality elements. It is not known what effects would take place with respect to land use, water supply, and cultural elements, while minimally positive recreation benefits would result from such actions.

Social and economic benefits would accrue from the flood protection and flooding reductions that would stem from the projects. About 70,000 acres in the subbasin would be afforded such protection if both alternatives were selected. There are very few recreational sites located near the river, although there may be some small municipal parks. One of the channel diversions could affect the Red Lake River, which is a state canoe river in Minnesota. Biological and water quality elements would

Table 21

ASSESSMENT OF MEASURES, BY RESOURCE ELEMENT, MAIN STEM SUBBASIN

Measures	Social	Economics	Use Land	Biology	Water Quality	Water Supply	Cultural	Recreation
Agricultural Levees--Canadian/U.S. Border to Grand Forks (1% Flood)	MaB	MaB	MiA	MaB	MiA	NKE	?	MiB
Agricultural Levees--Grand Forks to Breckenridge/Wahpeton (1% Flood)	MoB	MoB	MiA	MoB	MiA	NKE	?	MiB
Channel Modification--International Boundary to Grand Forks (10% Flood)	MaB	MaB	MoA	MaA	MaA	NKE	NKE	NKE
Channel Modification--Perley to Fargo (10% Flood)	MaB	MaB	MoA	MaA	MaA	NKE	NKE	NKE
Tributary Reservoirs (24% Flood)	MoB	MoB	MiA	MoA	MiB	NKE	NKE	MiB
Comstock Coulee Watershed (10% Flood)	MiB	MiB	MiA	MoA	MoA	NKE	NKE	NKE
Flood Protection for Noyes, Minnesota (1% Flood)	MiB	MiB	NKE	MiA	NKE	NKE	NKE	NKE
Flood Protection for St. Vincent, Minnesota (1% Flood)	MiB	MiB	NKE	MiA	NKE	NKE	NKE	NKE
Flood Protection for Bowesmont, North Dakota (1% Flood)	MiB	MiB	NKE	MiA	NKE	NKE	NKE	NKE
Flood Protection for Robbin, Minnesota (1% Flood)	MiB	MiB	NKE	MiA	NKE	NKE	NKE	NKE
Flood Protection for Drayton, North Dakota (1% Flood)	MiB	MiB	NKE	MiA	NKE	NKE	NKE	NKE
Flood Protection for East Grand Forks, Minnesota (1% Flood)	MoB	MoB	NKE	MiA	NKE	NKE	NKE	NKE
Flood Protection for Halstad, Minnesota (1% Flood)	MiB	MiB	NKE	MiA	NKE	NKE	NKE	NKE
Flood Protection for Perley, Minnesota (1% Flood)	MiB	MiB	NKE	MiA	NKE	NKE	NKE	NKE
Flood Protection for Breckenridge, Minnesota (1% Flood)	MoB	MoB	NKE	MiA	NKE	NKE	NKE	NKE
Flood Protection for Argusville, North Dakota (1% Flood)	MiB	MiB	NKE	MiA	NKE	NKE	NKE	NKE
Flood Protection for Brooktree Park, North Dakota (1% Flood)	MiB	MiB	NKE	MiA	NKE	NKE	NKE	NKE
Flood Protection for Harwood, North Dakota (1% Flood)	MiB	MiB	NKE	MiA	NKE	NKE	NKE	NKE
Flood Protection for Rivertree, North Dakota (1% Flood)	MiB	MiB	NKE	MiA	NKE	NKE	NKE	NKE
Flood Protection for Wahpeton, North Dakota (1% Flood)	MoB	MoB	NKE	MiA	NKE	NKE	NKE	NKE
Farmstead Levees (1% Flood)	MiB	MiB	NKE	NKE	NKE	NKE	NKE	NKE

Note: NKE = No Know Effect
MiA = Minimally Adverse
MoA = Moderately Adverse
MaA = Maximally Adverse
MiB = Minimally Beneficial
MoB = Moderately Beneficial
MaB = Maximally Beneficial

Source: Gulf South Research Institute.

be affected negatively by dredging activities, placement of dredged material, vegetation removal, and temporary turbidity. Water quality should, however, improve in the long run as stream flows are enhanced.

Farmstead Levees

Minimally beneficial economic and social effects would result from the protection of several farmsteads in the 100-year floodplain. All other resource elements would not be significantly affected, although consideration must be given to public health and aesthetic factors prior to their construction.

Agricultural Levees

The proposed agricultural levees would provide protection against a 100-year frequency flood for 110,000 to 280,000 acres and would range from moderately to maximally beneficial from an economic and social standpoint. The levees would provide primary benefits in the way of economic advantages to most of the agricultural lands and urban communities in the flood prone areas of the Red River (reduced flooding, earlier planting dates, fewer crop losses, etc.). Most of the social benefits would accrue from reduced flood damages to residences and farmsteads, fewer rural community disruptions, and reduced threats to public health and safety during flood periods. Adverse social effects would occur because mainly agricultural lands would be needed to provide for rights-of-way and easements.

Moderate to maximum beneficial effects are anticipated for wildlife resources, since the large setbacks would induce development of a riparian community. Adverse effects would occur to land use (possible induced clearings) and to water quality as a result of increased turbidity from construction activities, but the effects would be minimal. Recreation would receive minimally beneficial effects if any small parks are located near the river. Water supply and cultural elements would not be affected.

Urban Levees—Noyes, St. Vincent, Robbin, East Grand Forks Halstad, Perley, and Breckenridge, Minnesota; Bowesmont, Drayton, Argusville, Brooktree Park, Harwood, Rivertree, and Wahpeton, North Dakota

Prevention of flood damages in these cities would range from minimally to moderately beneficial social and economic effects to the communities and the subbasin. There beneficial effects include the reduction or

prevention of damages to and/or loss of personal property, the potential for disruptions in the delivery of emergency services, drains on community services, temporary or permanent loss of community facilities, loss of community tax base, and losses in personal income. In addition, such measures would serve to reduce many of the negative behavioral consequences associated with flooding problems. No or negligible effects would probably be experienced by land use, water quality and supply, cultural elements, and recreational elements.

Minimally adverse environmental and biological impacts would accrue as a result of project construction. Some streamside floodplain vegetation would be destroyed by project construction, and there would be minor degradation in aesthetic qualities and temporary air and noise pollution.

Tributary Reservoirs

Storage reservoirs on the tributaries of the Red River with a total capacity of 806,200 acre-feet would have moderately beneficial social and economic effects. The benefits would accrue mostly from protecting about 16,000 acres from flooding. Recreation would have minimally beneficial effects if the reservoirs were used for multiple purposes, thereby increasing recreation potentials. Minimally adverse effects would be experienced by land use elements as a result of changes in use and development. Moderately adverse results would be experienced by biological elements due to temporary disruption during construction, changes in existing habitat and increased turbidity. Water quality downstream would possibly experience minimally beneficial effects because the reservoir would act as a trap for sediments.

Land Treatment and Channel Improvement--Comstock Coulee Watershed

Flood damage reduction measures that consist of channel improvements, stabilization structures, ditch and drainage construction, and land treatment measures in Comstock Coulee Watershed will have minimally beneficial social and economic effects in the subbasin. These improvements would provide flood protection for a 105-square mile watershed. Biological and water quality elements would be moderately adversely affected by

dredging activities, vegetation removal, and temporary turbidity. Water quality should, however, improve in the long run as stream flows are enhanced. No known effects would occur to the water supply, cultural, and recreation resource elements.

X. EVALUATION

X. EVALUATION

Nine alternative measures considered for the subbasin have benefit/cost ratios that exceed unity. They are urban flood protection measures for Bowesmont, Robbin, Perley, Argusville, Brooktree, Harwood and Rivertree; channel modifications from Perley to Fargo; and the farmstead levees.

The channel improvements from Perley to Fargo would afford protection to some 20,000 acres and would best meet the National Economic Development (NED) objective and would have the highest net economic benefits. The Social Well-Being (SWB) account would be enhanced by public health and safety improvements, local flood damage reductions and an overall reduction of the dislocations stemming from such disasters. The Environmental Quality (EQ) account would receive basic changes, most of which would be negative, particularly for biological and water quality elements.

It is noteworthy that an economic evaluation of agricultural levees from Grand Forks to the Canadian border and from Breckenridge/Wahpeton to Grand Forks yields a cumulative benefit/cost ratio of 0.65, with most of the $4.4 million average annual benefits being urban. There are many towns and agricultural lands near the main stem of the Red River that are affected by its flooding but that are actually located in other subbasins. The benefits from such levees to other areas should be considered in future analyses. Further analysis should also be conducted into the possible significance on benefit/cost calculations of changing the flood stage levee criterion established by the two states. This analysis should include a social and environmental assessment of this alternative and particularly with respect to its effects on the water quality and fishery resource of the Red River, the floodplain riparian vegetation and on Canada.

XI. ADDITIONAL STUDY NEEDS

XI. ADDITIONAL STUDY NEEDS

This report was developed almost entirely on the basis of secondary information from readily available planning documents. Data available from state and Federal agencies were not fully canvassed, and only a limited number of calls were made to the area. In particular, state university libraries and department resources could not be fully utilized. Thus, the document aims only at a broad-brush perspective. In order to provide a more detailed and in-depth analysis of subbasin resources, problems, and potential solutions, the following additional study needs would have to be fulfilled:

1. An analysis needs to be made of the technical and economic feasibility of building levees along the Main Stem of the Red River and up the major tributaries to high ground disregarding the state criterion for flood stages. This analysis should include a social and environmental impact component, with particular stress on the effect on Canada.
2. A literature search should be conducted to obtain available biological data for the subbasin. Fieldwork should be planned to fill in any data gaps which exist with the end result of obtaining good baseline data for the Main Stem. This includes those areas where new flood control measures have been proposed, as well as updating any data for those projects which have been previously studied.
3. Areas of high environmental quality (e.g., prairie remnants) should be identified and inventoried within the subbasin.
4. Updated knowledge of the location, areal extent, and types of wetlands occurring within the specific subbasin boundaries would be extremely useful in providing a comparison for documenting wetland losses since the 1964 inventory.
5. Primary sediment quality data need to be obtained to characterize baseline conditions in the streams of the subbasin, particularly in those areas where flood control measures have been proposed.
6. Information pertaining to wastewater management needs to be updated.
7. The information obtained in items 1-5 above would provide an important data base upon which an impact evaluation of proposed flood control measures can be performed and would provide information relative to the cumulative effects of flood control projects on environmental resources in the subbasin. These projects include those that are in-place or proposed.

8. Nonstructural flood damage reduction measures should be thoroughly explored such as those listed below.

- Establishment of buffer areas and curtailment of inappropriate residential, commercial, and other development in floodplains.
- Maintenance and enhancement of existing riparian vegetation along the Red River and tributaries to conserve and restore wildlife habitats, help control wind and streambank erosion, retain soil on the land, and to reduce the amount of sediment, nutrients, and other pollutants entering waterways.
- Maintenance of grassed waterways to reduce erosion.
- Establishment of vegetation in areas of critical erosion.
- Determination of the feasibility of installing water control structures at existing culverts to retain water in drainage ditches for longer periods of time during critical runoff periods to minimize flooding in downstream areas.
- Determination of the feasibility of utilizing "on-farm storage" to control runoff through such means as natural storage areas and control structures on existing culverts.
- Prevention of overgrazing on grasslands and utilization of sound agricultural land use practices.
- Provision for strict enforcement of floodplain management programs within the subbasin.

9. The potentiality for land treatment measures (e.g., erosion control measures such as cover crops, green belts, reduction in fall tillage, etc.) needs to be throughly investigated.

10. The people of the subbasin need to be included in further water resources planning efforts. A public involvement program would provide more complete information on water resource problems and opportunities than is presently available.

11. More study is needed to determine the precise nature of the water supply problems and potential solutions.

12. Potentialities for floodwater storage in present drainage ditches need to be investigated.

13. The effect of drainage works on flood discharges and stages is unknown at present. It would take additional, more detailed studies to determine the extent and effect of reduced natural storage.

14. Land use within the floodplain needs to be precisely identified.

15. An adequate 100-year floodplain map needs to be developed. Also, the extent of floodplains for smaller frequency storms needs to be delineated.

16. More gauging stations need to be developed to provide hydrologic data for establishing flood frequencies and rating curves.

17. Channel cross-sections of the various streams need to be prepared for flood control planning purposes.

18. Crop distribution in the floodplain needs to be precisely identified through contact with county agents, and average annual rural damages need to be updated.

19. The irrigation potentials of the subbasin soils need to be investigated.

20. A comprehensive and up-dated inventory of recreation sites would be required to accurately identify resources.

21. Studies are needed to determine additional demand for recreational facilities, usage of existing facilities, and potential sites.

22. A regional supply and demand analysis for hunting, fishing, and other water based or related recreational pursuits is needed in the North Dakota portion of the subbasin.

23. Whether forested acreages in the floodplain are increasing or declining needs to be precisely determined.

24. A detailed institutional analysis of the subbasin is needed, including a detailed study of the objectives, goals, and programs of the many institutional entities involved in water resources planning, particularly at the local level. These studies will help in determining the most efficient institutional approach to the resolution of flooding problems in the subbasin.

25. A detailed social profile of the subbasin is needed.

26. Urban damages need to be recomputed in a systematic fashion.

27. A review of secondary sources and systematic field reconnaissance is needed to identify archaeological and historical sites and to determine their eligibility for nomination to the National Register of Historic Places.

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Appendix A

INVENTORY OF OUTDOOR RECREATIONAL FACILITIES (WILDLIFE MANAGEMENT AREAS) MAIN STEM SUBBASIN

Appendix A

INVENTORY OF OUTDOOR RECREATIONAL FACILITIES (WILDLIFE MANAGEMENT AREAS) MAIN STEM SUBBASIN

Number	Name	Administration	Location	Acres	Campgrounds [2]	Playground	Athletic Field [3]	Golf Courses [4]	Boat Ramps	Picnic Tables	Beach	Pool	Trails [5]
1	Deerwood WMA	State	Kittson Co. 15946W36 *Karlstad*	320.0									
2	Egolfson WMA	State	Pembina Co. 16050W20 Drayton	23.0									
3	Belgium WMA	State	Polk Co. 15246W16 Belgium Township	112.1									
4	Akron WMA	State	Wilkin Co. 13646W35 Breckenridge	545.0									
5	Oscar WMA	State	Otter Tail Co. 1344W20 Rothsay	90.0									
△	Drayton City Park	Municipal	Pembina Co. Drayton	62.0	8	1	3			11		1	
△	Sherlock Municipal Park	Municipal	Polk Co. 15149W01 East Grand Forks	20.5		X		9					
△	Goosebury Mound Municipal Park	Municipal	Clay Co. 13948W18 Moorhead	51.1						74			6
△	Moorhead Safety Rest	State	Clay Co. 13948W20 Moorhead	24.0						5			
△	Wells Municipal Park	Municipal	Wilkin Co. 13247W09 Breckenridge	24.0	15	X		18		20			X

-continued-

Appendix A (Cont'd)

INVENTORY OF OUTDOOR RECREATIONAL FACILITIES (WILDLIFE MANAGEMENT AREAS) MAIN STEM SUBBASIN

Number	Name	Administration	Location	Acres	Campgrounds[2]	Playground	Athletic Field[3]	Golf Courses[4]	Boat Ramps	Picnic Tables	Beach	Pool	Trails[5]
1	Drayton Golf Course	Municipal	Pembina Co. Drayton	50.0		1		9					3.5
2	Karlstad Golf Club	Private	Kittson Co. 15945W18 Karlstad	41.0		X		9		5			
3	East Grand Forks Rod and Gun Club	Private	Polk Co. 15350W16 East Grand Forks	40.0									
4	Valley Golf Association Golf Course	Municipal	Polk Co. 15250W34 East Grand Forks	73.0				9					
5	Grand Forks Speedway	Private	Grand Forks County Grand Forks	30.0									
6	Grand Forks Country Club	Private	Grand Forks County Grand Forks	232.0				18				1	
7	Winston Register Stables	Private	Grand Forks County Grand Forks	15.0									10
8	Grand Forks Rod and Gun Club	Private	Grand Forks County Grand Forks	20.0									
9	Ray Richards Golf Course	State	Grand Forks County University of North Dakota Grand Forks	80.0									

-continued-

Appendix A (Cont'd)

INVENTORY OF OUTDOOR RECREATIONAL FACILITIES (WILDLIFE MANAGEMENT AREAS) MAIN STEM SUBBASIN

Number	Name	Administration	Location	Acres	Campgrounds[2]	Playground	Athletic Field[3]	Golf Courses[4]	Boat Ramps	Picnic Tables	Beach	Pool	Trails[5]
10	Fargo Gun Club	Private	Cass Co. Fargo	60.0									
11	Interstate Gun Club	Private	Cass Co. West Fargo	28.0									
12	NW Drive Ponyland	Private	Cass Co. Fargo	30.0									
13	Dilworth Athletic Complex	School	Clay Co. 13948W02 Dilworth	18.0		X	18						
14	Moorhead Country Club	Private	Clay Co. 14048W29 Moorhead	120.0				18					
15	Concordia College	Private	Clay Co. 13948W29 Moorhead	120.0			60						
16	Town and Country Golf	Private	Clay Co. 13948W31 Moorhead	21.0				9					
17	Moorhead Senior High Athletic Field	School	Clay Co. 13948W00 Moorhead	60.0			25						
18	Bois de Sioux Golf Club	Private	Wilkin Co. 13247W05 Breckenridge	63.9				9					

[1]Facilities included are those with 15 or more acres.

[2]Number of campsites.

[3]Number of fields.

[4]Number of holes.

[5]Number of miles.

Sources: Minnesota Department of Natural Resources, Division of Parks and Recreation.

North Dakota State and Recreation Department, Inventory of North Dakota Outdoor Recreational Facilities, 1979.

Gulf South Research Institute.

Appendix B
COMMENTS

Appendix B
COMMENTS

The purpose of this subbasin report was to provide an overview of the water and related resource problems and needs and to assess potential solutions. Toward this end, draft copies of this report were circulated to Federal, State, and local agencies and comments were sought.

This review resulted in complete and factual documentation. Thus, the study should serve as a building block for the timely completion of future water resource efforts within the subbasin. Further cooperative efforts are, however, needed to evaluate these tentative results and to develop potential solutions.

A distribution list and copies of the comments made with respect to the draft report are included as part of this appendix. Comments that resulted in specific modifications to the draft text are marked by an asterisk.

DEPARTMENT OF THE ARMY
ST PAUL DISTRICT CORPS OF ENGINEERS
1135 U S POST OFFICE & CUSTOM HOUSE
ST PAUL, MINNESOTA 55101

REPLY TO
ATTENTION OF:
NCSED-PB

24 November 1980

Mr. Mike Liffmann
Project Manager
Gulf South Research Institute
8000 GSRI Avenue
Baton Rouge, Louisiana 70808

Dear Mr. Liffmann:

The draft Main Stem subbasin report was distributed for review and comment. Interagency comments will be provided when they are received.

a. Inclosure 1 is the general office comments that need to be considered when preparing the final Main Stem and other subbasin reports.

b. Inclosure 2 identifies specific office concerns that are applicable to the draft Main Stem subbasin report.

If you have any questions on our comments or proposed modifications, please contact us.

Sincerely,

Louis Kowalski

LOUIS KOWALSKI
Chief, Planning Branch
Engineering Division

2 Incl
As stated

United States Department of the Interior
FISH AND WILDLIFE SERVICE
AREA OFFICE—NORTH DAKOTA
1500 CAPITOL AVENUE
[redacted]
BISMARCK, NORTH DAKOTA 58501

Colonel William W. Badger, District Engineer
St. Paul District, Corps of Engineers
1135 U.S. Post Office & Custom House
St. Paul, Minnesota 55101

Dear Colonel Badger:

This letter provides U.S. Fish and Wildlife Service (FWS) comments on the Draft Reconnaissance Report recently compiled by the Gulf South Research Institute for the Mainstem Subbasin along the Red River of the North in Minnesota and North Dakota (your ref: NCSED-PB).

As expressed in our comments on previous subbasin reports, our concerns are associated with the woodland, grassland, wetland, riverine and riparian flood-plain habitats that remain within the mainstem subbasin. Most of the woodland, grassland and wetland habitat in the subbasin has been converted to agricultural uses. Remaining woodland vegetation has been reduced to only 1.1 percent of the total subbasin area and is primarily confined to the flood plain of the Red River of the North and along the major tributary streams. With the exception of a few scattered marshes owned by state and federal agencies, most wetlands have been drained and converted to agricultural uses. We fully agree with the statements on pages 14, 34, 48 and 49 of the report that these remaining woodland, grassland and wetland areas are significant and need to be protected, conserved and enhanced within the subbasin.

The report indicated that 90 percent of the subbasin's land area is under cultivation. We concur that the clearing of timber, construction of drainage ditches, intensive drainage of wetlands, conversion of grassland to cropland and continued fall tillage and other unsound agricultural land-use practices have not only significantly reduced the above habitat types, but also have substantially contributed to the increased flooding, erosion, water quality, water supply and water-related land resource problems within the subbasin.

In addition, the Red River of the North is of major concern because it contains a good sport fishery which includes channel catfish, walleye, northern pike, sauger, crappie, bullheads, yellow perch, goldeye, freshwater drum and rock bass. The Red River is also an important water supply source and recreational resource for the subbasin. As such, no measure should be undertaken within the subbasin that would further reduce the water quality or inappropriately degrade this extremely important riverine resource and associated woodland, riparian corridor.

The report primarily addressed 21 structural measures that have been considered to date to help reduce the flooding problems within the subbasin. The report indicated, however, that only nine of these measures (flood protection for seven urban areas, farmstead levees and channel modifications along the Red

River of the North between Perley and Fargo) had favorable B/C ratios and appear to be economically feasible. Our comments relative to these various structural measures (urban levees, farmstead levees and channelization projects) are similar to those expressed on previous subbasin reports. We are particularly concerned about the emphasis that is still being made within these subbasin reports on "protective" type structural measures such as agricultural levees and channelization projects. We believe the causes of the flood damage problems (wetland drainage, channelization, land-use changes, unsound agricultural land-use practices, etc.) should be addressed prior to the implementation of structural measures. Pursuing a "protective" as opposed to a "preventive" approach to the flooding problems would allow these unsound land-use practices to continue and would likely further increase the flooding and other related land resource problems within the Red River Basin. In our opinion, constructing agricultural levees along both sides of the Red River and along the lower reaches of its major tributaries to protect agricultural land within the flood plain would not only be inappropriate for the reasons addressed above, but also would not provide an effective long-term solution to the flooding problems along the Red River of the North or within the Red River Basin. Further, the Minnesota-North Dakota agricultural levee criteria presently stipulates that flood stages not be increased by more than 0.5 feet. If these criteria are changed, or disregarded, allowing new levees to be constructed closer to the river to protect more agricultural land, downstream flooding problems would be more substantial. We also do not believe constructing agricultural levees along both sides of the Red River of the North or along the major tributary streams, simply to allow local landowners to continue to farm within the flood plain directly adjacent to these rivers would be in the best overall public interest. People living in downstream areas should not have to continue to suffer hardships or the public be expected to continue to pay for increasing annual flood damages, so that the additional economic gains obtained by local landowners farming within these flood damage prone areas can be maintained.

Although some nonstructural measures were briefly discussed on pages 70, 71, 72, 85, 86, 87, 88 and 99 of the report, we believe that nonstructural measures should be much more greatly emphasized. In our opinion, a plan involving a combination of both nonstructural as well as structural measures (as identified on page 4 of our previous letter on the Draft Reconnaissance Report for the Tamarac River Subbasin) would be the most appropriate solution to the flooding and other water related land resources problems within the subbasin and should be implemented.

We agree that additional studies (particularly Nos. 2, 4, 8, 9, 11, 12, 13 and 23 on pages 98-100 of the report) need to be undertaken to provide a more detailed and indepth analysis of existing subbasin problems and the potential solutions to many of these problems.

In addition, we suggest that the following changes be made in the final mainstem subbasin report:

*1. Page 29, second paragraph, last sentence - We suggest this sentence, "These practices will continue, but at a slower rate" be deleted. These unsound land-use practices must be curtailed within the subbasin.

*2. Page 34, second paragraph, seventh sentence - We suggest this sentence be changed to read: "The most common breeding species are the mallard, blue-winged teal, pintail, gadwall, wood duck and northern shoveler (data from NDGFD and USFWS, 1978; USFWS, 1980)".

*3. Page 37, first paragraph, third sentence - We suggest this sentence, "Much of the mainstem and its tributaries have been channelized, which resulted in water quality degradation" be rewritten. Much of the Red River of the North Mainstem has not been channelized. We concur that many of the tributatries to the Red River have been altered by SCS and Corps channelization projects.

*4. Page 37, second paragraph, first sentence - Delete the words "U.S. Fish and Wildlife Service" in this sentence.

*5. Page 50, Table 10 - We suggest the heading for this table be changed to read "1964 Wetland Inventory Data for 10 Counties in Minnesota and North Dakota Included By the Mainstem Subbasin".

*6. Page 51, first paragraph, second sentence - We suggest this sentence be changed to read: "These data show that the numbers and acreage of Type III, IV and V wetlands in Polk, Clay, Wilkin and Ottertail Counties have been reduced by 5,532 and 4,564 acres, respectively, during the 10-year period from 1964 to 1974".

*7. Page 51, first paragraph, seventh sentence - We suggest this sentence be changed to read: "Although no acreage figures are available for the North Dakota portion of the subbasin, most of the wetlands in eastern North Dakota have also been drained and converted to cropland".

*8. Page 51, first paragraph, "Waterfowl Production Areas" - We suggest this paragraph be changed to read as follows:

"Waterfowl Production Areas (WPA's) are wetland areas that the U.S. Fish and Wildlife Service (FWS) has either acquired through fee title, or obtained an easement interest in, to preserve valuable breeding, nesting and feeding habitat for migratory waterfowl. These wetland areas are purchased, or an easement interest obtained, with funds received from the sale of migratory bird hunting and conservation stamps (Duck Stamps). These WPA's are significant because they provide the public with a great variety of wildlife-oriented recreational opportunities, as well as provide valuable habitat for migratory waterfowl and many other forms of wildlife. FWS is responsible for the compatibility determinations (uses) and the issuance and denial of permits involving these lands. WPA's acquired in fee title are managed for optimum wildlife production, particularly waterfowl. On easement WPA's, the rights acquired are limited to the burning, draining and filling of wetland basins and right of access. All other property rights remain with the landowners. The approximate locations of WPA's acquired in fee within the subbasin are shown in Figure IV."

* 9. Page 55, Figure IV - Place "fee tracts" in parenthesis after the legend.

*10. Page 58, first paragraph, first sentence, "Rare and Unique Plants" - Remove "(no date)" and insert "(1976)".

*11. Page 68, first paragraph, second sentence, "Structural Measures" - We suggest this sentence be changed to read: "In addition to projects constructed along the mainstem, some existing SCS and Corps' projects along tributary streams have also reduced flooding along the mainstem. However, in most instances, these channelization and drainage projects have contributed to increased flooding and flood damages in downstream areas and along the Red River of the North".

*12. Page 73, second paragraph, last sentence - We suggest this sentence be changed to read: "Flood-plain management programs would help reduce future flood losses; however, recurring flooding along the mainstem will continue to be a serious problem, and additional measures (both structural and nonstructural) will be required to significantly reduce the flood damages within the subbasin".

*13. Page 75, "Planning Objective No. 4" - We suggest this sentence be changed to read: "Contribute to the improvement of water quality in the Red River and other rivers and streams within the subbasin".

14. Page 86, fourth paragraph, first sentence - We suggest this sentence be changed to read: "Development of a basinwide drainage plan would assist in making orderly and rational decisions with respect to the justification for implementing any future drainage projects within the Red River Basin. Such a plan should be based on sound hydrology and hydraulic analysis and a thorough understanding of the economic, social and environmental consequences of these drainage projects".

*15. Page 97, second paragraph, second sentence - We suggest the word "local" be placed in front of the words "flood damage reduction" in this sentence. This channelization project would contribute to increased flooding and flood damages in downstream areas along the Red River of the North and in Canada.

*16. Page 97, last paragraph - We suggest the following sentence be added at the end of this paragraph: "This analysis should include a social and environmental assessment of this alternative and particularly with respect to its effects on the water quality and fishery resource of the Red River, the flood-plain riparian vegetation and on Canada".

*17. Page 104, Bibliography - Include the following reference (see page 72) on this page:

National Wetlands Technical Council, 1978. "Scientists Report on the National Symposium on Wetlands." 129 pp.

These comments have been prepared under the authority of and in accordance with the provisions of the Fish and Wildlife Coordination Act (48 Stat. 401, as amended; 16 U.S.C. 661 et seq.) and other authorities mandating Department of the Interior concern for environmental values. They are also consistent with the intent of the National Environmental Policy Act of 1969.

The opportunity to review and comment on the Draft Reconnaissance Report for the Red River Mainstem Subbasin is appreciated.

Sincerely yours,

Gilbert E. Key

Gilbert E. Key
Area Manager

DAKOTA
WATER COMMISSION
bismarck 58505
north dakota

December 10, 1980

Col. William W. Badger, District Engineer
St. Paul District Corps of Engineers
1135 U.S. Post Office & Customhouse
St. Paul, MN 55101

RE: Red River Mainstem Study - SWC Project #1701

Dear Col. Badger:

This letter is to provide comments on the draft reports for the Maple River Subbasin, Wild Rice River Subbasin, and Mainstem Subbasin for the Red River of the North Reconnaissance Study.

In the Maple River Subbasin Report, the implication is made that the only forms of valuable recreational resource are large bodies of water and forest tracks. This is not true, since even within the Maple River Basin there are areas suitable for canoeing and hiking which are considered valuable by some. Other forms of limited recreation do exist, as is mentioned in the report. The section on water quality problems should be quantified if possible. Use of such terms as "excessive", "insufficient", and "exceeds", can be very deceiving when not quantified. Quantified soil loss figures should be available from the Soil Conservation Service. These figures could be used to quantify the erosion problems. The North Dakota State Health Department should be contacted to determine whether or not improved waste water treatment facilities are planned for the communities within the subbasin.

Under the section titled "Public Perception of Problems and Solutions", mention should be made that there are county water management boards which have been organized for years. These boards could help in providing information for this section. Credit should also be given to the Soil Conservation Service in this section for their involvement in the watershed planning or P.L. 566 Program. In the "Transportation Network" section, a statement should be made as to the condition of the transportation system within the subbasin, excluding the major state and federal highways. Throughout the report, reference is made to ground wells. The word "ground" should be deleted from this phrase, since ground and well are redundant in this instance. The section entitled "Aesthetics"

should be deleted from the report. Since aesthetically appealing views are not defined in the report, they may mean different things to different people. For those people living within the subbasin, the existing landforms although featureless, may be very appealing to them.

On page 33, reference is made to the "Cernhous Report". Since this report is not thoroughly documented, nor is complete evidence available to support all of the findings of the report, reference should not be made to it. Also on that page, the section addressing the number of wetland acres remaining in the subbasin should be deleted. The method used to expand the 1964 survey may not be very scientific since the 1964 survey may have not been a random sample. Also, the section is very confusing since the information appears to pertain only to 1964 data, and it would be impossible to update this to 1980 data. In the "Waterfowl Production Area" section, the implication is given that all easement areas that are obtained through the wetland easement program are considered to be waterfowl production areas. This is not true, since generally Waterfowl Production Areas are only those areas owned in fee title by the U.S. Fish and Wildlife Service.

In the section entitled "Threatened and Endangered Species", mention should be made as to when the black-nose shiner was actually last recorded in the Maple River. Under "Other Important Species", mention should also be made as to when the three species mentioned were last verified within the subbasin. In the "Rare and Unique Plants" section, were the 12 species listed actually recorded within the Maple River Subbasin, or were they just recorded within those counties?

On page 45, mention is made of seven state agencies which are involved directly in water and related land resources planning. These seven agencies should be listed. Also on that page, in the final paragraph, mention should be made of the state agencies, such as the State Water Commission, which should be consulted in devising flood control measures for the subbasin. Again on page 48, reference is made to the "Cernhous Report". As mentioned before, this reference should not be made. Further in that paragraph, reference is made to a statistical study, not being familiar with this study, I do not believe that it could be applicable to the watersheds within North Dakota. Because of the characteristics of watersheds within North Dakota, it would be impossible to realize a 75-80% reduction in flood peaks if only 30% of the watershed was in wetlands. This would almost imply that there was virtually no runoff from the remaining 70% of the watershed.

In the chapter entitled "Formulation of Alternative Measures", a recommendation is made to construct agricultural levees along the Maple River. The basis for the spacing of these levees should be mentioned. At a minimum, the spacing should be such that the levees would comply

with criteria now in existence for the Red River, which does not allow for more than a six inch increase on the 100 year flood. In the chapter entitled "Assessment of Alternatives", the nonstructural measures should be mentioned and an estimate of the economic impact made.

In the Wild Rice River Subbasin Report, the statement is made that floods within the subbasin are almost an annual event. This statement should not be made unless it can be quantified and shown that floods do occur that frequently. The statement does imply that this frequent flooding causes damage. In some recent situations, flooding may occur but there may not be damage associated with it. In the section on "Waste Water Management", the statement is made that releases from inadequate treatment systems have severely degraded the river's water quality. The reference for this statement does not have a date; it is possible that since this reference was published that the communities within the basin have improved their waste water management systems. If this is true, that statement may not apply to existing conditions. On page 16, the statement is made that no watershed districts exist in the Wild Rice River basin. This is not true since there are water management boards within each county within the subbasin. On page 36, reference is made to a "high" table. This should be corrected to read "high ground-water" table.

The same comments which were made on the "Wetlands" section of the Maple River Subbasin Report would apply to the "Wetlands" section of the Wild Rice River Subbasin Report. The expansion of the 1964 data would not be accurate, and would not apply to today's conditions. On page 51, the State Water Commission should be listed as an agency to be consulted in future flood control planning. On page 54, reference is again made to the "Cernhous Report", which should be deleted. In that same paragraph, the same statistical studies as were referenced in the Maple River Subbasin Report are used. The same comment made regarding the Maple River Subbasin Report would apply here. In the "Assessment of Alternatives" chapter, a discussion should be made regarding nonstructural measures. The economic assessment of Alternative 1, Channel Improvements to 44 Miles of Antelope Creek, should be looked at more closely since the benefit/cost ratio comes very close to approaching unity. By using estimates from reports pertaining to other subbasins, it's very possible that there may be slight variations in the subbasins which could cause benefits to be slightly greater, thus this alternative should be carried forth to the "Evaluation" chapter.

In the Mainstem Subbasin Report, greater emphasis should be placed on the water supply problems being experienced by the City of Fargo. In 1977, Fargo had to import water from the Sheyenne River Basin to meet its water supply demands. In the"Public Perception of Problems and Solutions" section, mention should be made of the informal agreement

between the Lower Red River Watershed District and the Red River Joint Water Management Board. This informal agreement calls for cooperation between these two entities in attempting to manage the water of the Red River Basin.

* On pages 49 and 51, reference is again made to the 1964 Inventory of Wetlands. For the same reasons as mentioned earlier, reference to this particular inventory should be deleted. In the comparison made between the 1964 and the 1974 inventory within the Minnesota counties, it can be seen that expanding the 1964 data by multiple of four does not yield accurate estimates for a 100% survey.

* On Table 13, pages 56 and 57, a column should be added to show the most recent date of a confirmed siting of the threatened or endangered species. A similar column should be added to Table 14, for rare and unique plants.

On page 67, reference should be made to the two large water management entities which have authority within the Mainstem. These include the Lower Red River Watershed Board in Minnesota and the Red River Joint Water Management Board in North Dakota. On page 73, the statement is made that agricultural levees on the Mainstem have been instrumental in preventing agricultural losses. The quantified basis for this statement should be included. The statement should go on to say that the same agricultural levees have been instrumental in aggravating agricultural losses in unprotected areas.

* On page 76, the structural measure addressing agricultural levees should state that the levees would be constructed in compliance with the existing criteria and agreement between the states of North Dakota and Minnesota. This same statement should be added to the last paragraph on page 89, and also to the first paragraph on page 91. On page 91, separate benefit/cost ratios should be listed for each of the reservoirs included in Alternative 5.

Overall, all three reports contained much valuable information. It does appear as though these reports make a greater attempt at identifying water management problems which exist throughout the basins, and are not totally restrictive to flood control problems. This is an improvement over previous reports.

Sincerely,

Cary Backstrand
for

David A. Sprynczynatyk, P.E.
Director of Engineering

DAS:sh

GENERAL COMMENTS
DRAFT MAIN STEM SUBBASIN REPORT
(OCTOBER 1980)

(These comments apply to the entire report and all subsequent subbasin documents.)

1. Comments from Federal, State, and local agencies and a letter from the St. Paul District will be included in an appendix in each final subbasin and in the overall report. The format for the appendix will be:

a. Introduction - This section should stress:

(1) The importance of completing the study on time.

(2) That the purpose of the study is to advise other agencies and interests.

(3) The need for a selected review by various interests to provide complete and factual documentation.

(4) The use of the study as a building block for future water resource efforts.

(5) That cooperative efforts to evaluate results and develop solutions to remaining problems will be incorporated.

(6) A complete public involvement program when the study is finished.

b. The distribution list.

c. Copies of letters of comment.

Only comments that identify significant errors or need specific attention will be addressed in the final subbasin report. However, all comments incorporated should be identified with a marking system.

2. Care should be taken to ensure that similar data reported in the various draft reports are uniform, consistent, and accurate. For example, in the climate sections temperatures are recorded in ranges, means, and averages. Also, the numerical information used in the report should not be more accurate than the information from which it was developed. Many times the estimates given appear to be precise when in fact this is not the case.

3. The supporting information for alternatives including technical, economic, and environmental backup data should be provided (at least under separate cover).

4. All references by the same author and of the same year should be ranked (i.e., 1979a, 1979b, etc.) so that these references can be distinguished.

Incl 1

5. The evaluation section of each report is primarily the recommendations of the document. Generally only the alternatives which have a benefit-cost ratio greater than 1 are presented. Little attention is given to other less economically feasible alternatives that may be important in specific aspects of future flood damage reduction planning for the subbasin as well as the basin as a whole. Some of these alternatives may provide the necessary environmental or social conditions to warrant future attention. Therefore, this section should be expanded to provide the appropriate discussions.

6. The 1980 current normalized prices issued in October 1979 were revised in July 1980. Label all references to current normalized prices as "prerevision" or "postrevision" as appropriate.

7. Average annual damages and benefits should be reviewed based on the comments provided on the draft overall report.

8. In light of the identification of alternatives that disregard the State levee criteria, it is suggested that the final main stem report be revised to indicate the coordinated work and effort that went into the criteria development, what the criteria is and what its purpose is. This would help to understand the existing situation much better.

9. The lack of large lakes and sizable forest tracts combined with poor water quality in existing rivers severely limits the diversity of recreation opportunities in most subbasins. It is extremely important that alternative flood control measures be analyzed for their impacts on those areas that do contain large lakes, sizable forest tracts, and rivers with good water quality.

St. Paul District
Corps of Engineers
Specific Comments
on the
Draft Main Stem Subbasin Report
(October 1980)

* 1. Pages 1-3 - Additions to the list of comprehensive reports should include the following:

a. Red River of the North Basin Plan of Study for Water Resources Management prepared in April 1977 by the Army Corps of Engineers, St. Paul District.

b. Grand Forks-East Grand Forks Urban Water Resources Study, Stage 3 Water Supply Study Final Report prepared in March 1980 by Stanley Consultants, Muscatine, Iowa, for the Army Corps of Engineers, St. Paul District.

c. Grand Forks-East Grand Forks Wastewater Study, Stage 3 Grand Forks Combined Sewer Analysis prepared by Stanley Consultants, Muscatine, Iowa, for the Army Corps of Engineers, St. Paul District.

d. Grand Forks-East Grand Forks Urban Water Resources Study, Stage 3 Flood Control, Energy Conservation and Recreation, Public Involvement, and Plan Formulation Appendices prepared in December 1979 by the Army Corps of Engineers, St. Paul District.

e. Flood Emergency Plan for Grand Forks, North Dakota, prepared in August 1980 by the Army Corps of Engineers, St. Paul District.

f. City of East Grand Forks, Minnesota Civil Defense Flood Fight Plan prepared by Dr. Orley D. Gunderson, Civil Defense Director, and Floan-Sanders, Inc., Consulting Engineer, East Grand Forks, Minnesota, in September 1980 for the Army Corps of Engineers, St. Paul District.

g. Fargo-Moorhead Urban Water Resources Study Reconnaissance Report prepared in September 1980 by the Army Corps of Engineers, St. Paul District.

* 2. Page 2, No. 3 - Delete "Water Supply Appendix," and "Wastewater."

* 3. Page 5, sentence 2 - Delete after "...land," and add "which drains directly into the Red River main stem." As written, this sentence conflicts with the last sentence in the paragraph.

* 4. Page 5, paragraph 3, line 6 - Change "a gradient" to "an average gradient."

Incl 2

5. Page 6, Figure I - This map is difficult to read and should be improved. Also, add the communities of Pembina, Drayton, Bowesmont, Perley, Rivertree, Brooktree Park, Robin, and Harwood because each of these is discussed in the text.

6. Page 7, paragraph 1, last sentence - Change to include the fact that floods in the main stem subbasin can also be caused by unusually heavy rains occurring in either the tributary or main stem areas (i.e., the 1975 flood).

*7. Page 8, paragraph 2, last sentence - Between "are" and "localized" add "generally" and between "they" and "do" add "usually." Also after "...subbasins." add " ; however, the July 1975 storm was an exception."

8. Page 8, last paragraph - The "northward flow" concept should be deemphasized. Snowmelt over the entire basin occurs uniformly and seldom do ice and snow result in backwater flooding. Therefore, this factor may not be as important as was originally thought.

*9. Page 9, last paragraph - Before "600,000" add "about."

10. Page 10, Figure II - See specific comment 5.

*11. Page 16, Recreation Problems - While the main stem subbasin lacks large lakes for recreation purposes, this shortage is only a problem if no alternatives are available. Most subbasin residents are within easy driving distances of lakes suitable for water-based recreation. The lakes within Minnesota are heavily used by both Minnesota and North Dakota residents of the Red River Valley. Suggest tempering the paragraph or indicating what mileage is considered to be a "great distance."

*12. Page 17, paragraph 4 - This paragraph states that communities relying on surface water often experience water shortages during dry years. This is not correct. At present, the Red River with its existing tributary storage can adequately meet the municipal and industrial water supply requirements. In some cases groundwater is used to supplement surface water. Although this condition exists, it does not rule out the potential for water shortages should water use along the main stem continue to increase. This paragraph should be restated reflecting the above comments.

13. Page 17, Erosion Problems - Wind erosion probably constitutes a more serious threat to cropland than water erosion. It also adds to the problem of overland flooding by plugging ditches, culverts, etc. Wind erosion should be indicated and addressed as a major problem in this subbasin as well as other subbasins.

*14. Page 18, Irrigation - This paragraph implies that only impounded surface water is used as a source for irrigation. What about irrigation from wells as they also are used for irrigation in this area? This section should be clarified.

15. Page 18, last paragraph, 7th line - Airline distance? - Is this different than air miles? River miles should be used as it is the length of the river that should decrease the coliform bacteria.

16. Page 19, Public Perception of Problems and Solutions, paragraph 1 - While the public's perception of problems and solutions may be adequately defined for a reconnaissance report for this subbasin (unlike many of the subbasins), the use of "well defined" may be too strong a statement, since no formal studies of public perception have been conducted. The "public" may incompass a broader range of perceptions than those identified by the public meetings which have taken place. Suggest paragraph be rewritten to indicate this fact. This data would be generated by the social analysis identified as an additional study need on page 100 of this report.

*17. Page 21, Public Perception of Problems and Solutions, last paragraph - Change sentence (...it is evident that residents of the Red River Basin consider flood control...) to read (...it is evident that most residents of the Red River Basin consider flood control...). The rationale for this change is that the statement implies that this opinion is shared by all the residents of the basin. It is quite probable that some residents may think other water-related problems are more important; e.g., the farmer living in an upland area who has water supply problems.

*18. Page 22, paragraph 2, sentence 2 - Rephrase because this sentence does not support the first sentence which states that the basin population has steadily increased.

19. Page 24, Income - The distribution of income (such as percentage of population below the poverty level, etc.) should be included.

20. Pages 24 and 26, Income and Trade - What is the correction factor used to convert figures to 1979 dollars? It would be helpful if it were included.

*21. Page 25, paragraph 1, last sentence - This sentence states an average income figure for a whole state. The state should be identified, but better yet an average from both states should be used as the main stem subbasin includes portions of Minnesota and North Dakota.

22. Page 25, Agriculture - In addition to the factors noted on yield per acre, harvested acres, and total production for particular crops, it would be helpful if gross income per acre for particular crops were included. This information would give a better understanding of the relative importance of each crop. One other factor that would aid understanding of flooding problems is the differential in susceptibilities of crops to flood damages. Some crops are not as seriously affected by a flood event as others. In addition, the differential in costs per acre to plant particular crops would aid understanding.

23. Page 25, Table 4 - This table should be modified to reflect the importance of potatoes and sugar beets. This would help to present a more accurate picture of the agriculture situation in the subbasin.

24. Page 26, Agriculture - The sentence "It is primarily used for growing the previously named crops," should be deleted.

25. Page 29, paragraph 1 - The remaining 1.6 percent of land use should be identified.

26. Page 29, paragraph 3 - It should be indicated that the reasons identified are minor.

27. Page 29, Climate Section - The temperatures listed are in error. Please correct.

28. Page 31, paragraph 2, line 1 - "Parent" is misspelled.

29. Page 35, sentence 1 - Change "greater than 12 bird/1,000 miles" to "less than 12 birds/1,000 miles."

30. Page 38, last paragraph - Modify according to specific comment 12.

31. Page 39, paragraph 1 - The sugar beet plants in the Red River Valley use a closed circulation system. Therefore, they do not utilize "a great percentage" of the water supplies. The last sentence should be modified.

32. Page 43, paragraph 2 - The reason pre/proto-historic agricultural villages do not seem to have existed along the main stem is because systematic surveys to locate sites have yet to be undertaken along the river. Surveys along the river would probably locate these and other types of sites.

33. Page 43, paragraph 3 - The last sentence in the paragraph is inappropriate for the Cultural Elements section.

34. Page 44, paragraph 1 - Systematic surveys within the subbasin will probably locate many more significant sites. Therefore, change "might" to "will" in last sentence.

35. Page 47, paragraph 2 - A complete assessment of the subbasin's cultural resources is not possible because the total number of resources present in the area is unknown. Please change the second sentence to reflect this.

*36. Pages 49-51, and Discussion and Presentation of Tables 10, 11, and 12 - Because of the emphasis that has been placed on wetland storage for flood reduction, such generalizations on Type 1 wetland numbers and area is unrealistic. The indication from prior reports that Type 1 wetlands comprise about 60 percent of total wetland numbers and 10-15 percent of the total wetland acres may be valid, however, Table 10 shows these generalized percentages being rounded off to the nearest acre. The average area per wetland is 1.17 acres, which is comparable to the earlier averages for basins located above Grand Forks. Be cautious of the accuracy of the data since three counties were not inventoried this year. Also, Table 10 presents data for more than the four counties shown in the title. Tables 11 and 12 make suspect generalizations for the Main Stem subbasin based on the changes made in five Minnesota counties.

37. Page 54, Threatened or Endangered Species - This section should specify which species are considered threatened or endangered only by North Dakota or Minnesota, and which species are listed Federally as threatened or endangered by the U.S. Fish and Wildlife Service.

*38. Page 62, paragraph 1 - Modify to reflect general comment 6.

39. Page 65, Most Probable Environmental Conditions - Since the number of agricultural and farmstead levees will probably continue to increase in the future, it is likely that the environmental situation will change accordingly. Suggest a rewrite to reflect this potential future condition.

*40. Page 68, paragraph 1 - Delete "presently has authorized... Minnesota." and replace with "presently has an authorized project at East Grand Forks, Minnesota and is evaluating under Section 205 authority, the feasibility of flood control projects at Argusville, North Dakota and Halstad, Minnesota."

*41. Page 68, Item 4 - Delete and replace with "As part of the 1969, 1978, and 1979 flood emergency efforts, the Corps has constructed temporary levees at Fargo, Breckenridge, Wahpeton, Moorhead, Halstad, Grand Forks, East Grand Forks and a number of smaller communities located in the main stem subbasins. These emergency efforts have afforded protection for a particular flood event but are not considered adequate for permanent protection."

*42. Page 72 - The amount of flood peak reduction will depend upon location, type, and amount of wetland not just area of wetland.

* Second paragraph, second sentence: A statement regarding present indications of the role of wetland storage is not warranted. The implied magnitude of this role should <u>not</u> be "substantial" without extensive data and study backup. Therefore this statement may or may not be applicable in this basin.

*51. Page 89, last paragraph and page 91, first paragraph - Alternatives 1 and 2 should briefly add that these agricultural levees are in accordance with State's levee criteria.

52. Page 90, Table 20 - The costs per mile of channelization in alternatives 3 and 4 vary by 300 percent. These numbers should be reviewed for a possible inconsistancy.

53. Page 92, Channel Modifications - The assumption that long-term benefits in water quality would result from channelization is not valid.

54. Page 94, Agricultural Levees - In most cases it is not reasonable to assume that existing habitats will be improved or that new habitats will be created riverward of the agricultural levees. Farmers will continue to farm this land whenever possible. At best, adverse or beneficial impacts will be negligible.

*55. Page 97, paragraph 3 - Change the benefit-cost ratio of ".76" to ".67" to be consistent with the benefit-cost ratio on page 89.

*56. Page 100, Additional Study Needs - Number 24 is subsumed under number 25. Suggest the following combination of the two: "A detailed institutional analysis of the subbasin is needed, including a detailed study of the objectives, goals, and programs of the many institutional entities involved in water resources planning, particularly at the local level. These studies will help in determining the most efficient institutional approach to the resolution of flooding problems in the subbasin.

57. Page 100, Additional Study Needs - It should be noted in each subbasin report that the probability of institutional and social boundaries being the same as subbasin boundaries is remote, at best. Since this boundary-overlap exists, integrated basin-wide social and institutional analyses are desirable.

43. Page 72, last paragraph - This paragraph should be modified to reflect the fact that the flood emergency efforts accomplished over the last 10 to 11 years have been successful in reducing the magnitude of flood damages. These emergency efforts supplement the beneficial effects of existing measures.

* 44. Page 73, first sentence - Add "about" before "30". In the second sentence, "but" is misspelled.

* 45. Page 73 - The problems with the existing agricultural levees do not stem from the lack of authority by the Corps to regulate construction. This sentence has to be restated to consider the Corps as only a technical advisor to the existing situation.

* 46. Page 74, Planning Objectives - The second paragraph seems to be too strongly stated. The following rewrite is suggested:

  The development of planning objectives involved a broad-range analysis of the needs, opportunities, concerns, and constraints of the subbasin from the information that was available. On the basis of this analysis of the problems, needs, and desires that could be identified, the following planning objectives were established.

47. Page 76, Structural Measure 1 - It should be stated whether this measure is in accordance with State's criteria or not.

* 48. Page 79, Table 18 - Change the flood control storage (ac-ft) in Hust to "205,000" instead of "240,000."

* 49. Page 88, last paragraph - Not enough consideration is given to the development of nonstructural alternatives, other than those mentioned in previous Corps reports. There should be a more extensive discussion of the possible benefits and impacts of other types of nonstructural alternatives such as minimum fall tillage, on-farm retention of runoff, retention of water in drainage ditches during critical runoff periods, maintenance of grassed waterways, etc. This should be included if further study is warranted.

50. Pages 89-96 - References made to borrow pits and channelization impacts on existing and potential recreation opportunities should be considered in this section. Channel modifications and/or diversions not only alter the natural appearance of waterways, they also destroy, in many instances, the existing vegetation and fish habitat that originally attracted recreationists. Often, the resulting net benefits to recreationists turn out to be less than were available in the first place. In addition, the borrow pits created during levee construction could not be used to a significant degree by recreationists in this area.

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8